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CARPENTRY
JOINERY
STAIR BUILDING
GEOMETRICAL DRAWING
ARCHITECTURAL DRAWING
ESTIMATING AND CALCULATING QUANTITIES
SPECIFICATIONS

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CONTENTS

CARPENTRY	<i>Section</i>	<i>Page</i>
Province of Carpentry	9	1
Timber	9	2
Classes of Framed Structures	9	31
Joints	9	32
Framing	9	50
Sills, Posts, and Studs	9	50
Floors	9	51
Partitions	9	57
Framing of Roofs	9	65
Balloon-Frame Construction	9	100
Slow-Burning Construction	9	132

 JOINERY		
Province of Joinery	10	1
Joints	10	2
General Joinery	10	13
Provision for Expansion and Contraction	10	13
Interior Trim	10	14
Door Making	10	23
Windows	10	31
Splayed Work	10	56
Bending Wood	10	73
Veneering	10	77
Blinds	10	83
Hinges and Their Application	10	90
Interior Fittings	10	93
Exterior Joinery	10	101

STAIR BUILDING	<i>Section</i>	<i>Page</i>
Introduction	11	1
Stairway Construction	11	2
Details of Construction	11	6
Balustrades	11	18
Stairway Design	11	22
Ordinary Forms of Stairways	11	22
Special Forms of Stairways	11	47
Wainscoting	11	54
 GEOMETRICAL DRAWING		
Instruments and Materials	13	1
Lettering	13	18
Plates	13	26
The Representation of Objects	13	48
Projections I	13	55
Projections II	13	61
Conic Sections	13	65
Intersections and Developments	13	67
Shade Lines	13	73
 ARCHITECTURAL DRAWING		
Scales	14	1
Moldings	14	4
Description of Arches	14	10
Full-Size Details	14	15
Details	14	16
Mullion Window	14	19
Details of Vestibule	14	24
Steel Columns and Connections	14	27
First-Story Plan	14	31
Second-Story Plan	14	45
Constructive Details	14	52
Front Elevation	14	68
Sectional Elevation	14	82
Tracings	14	87
Blueprinting	14	88
Drafting-Room Practice	14	93

CONTENTS

v

ESTIMATING AND CALCULATING QUANTITIES	<i>Section</i>	<i>Page</i>
Introduction	19	1
Principles of Estimating	19	2
Approximate Estimating	19	3
Estimating Schedule	19	4
Excavation	19	11
Masonry	19	13
Brickwork	19	17
Carpentry	19	19
Roofing	19	27
Plastering	19	35
Joinery	19	37
Hardware	19	42
Heating and Ventilating System	19	42
Plumbing and Gas-Fitting	19	43
Painting and Papering	19	46
Glazing	19	50
Example in Estimating	19	52

SPECIFICATIONS

Introduction	23	1
Form of Specification	23	4
Heading and General-Condition Clause	23	4
Masonry	23	10
Carpenter Work	23	23
Hardware	23	39
Plumbing	23	43
Gas-Fitting	23	52
Heating	23	53
Painting	23	54
Electrical Work	23	56

CARPENTRY.

PROVINCE OF CARPENTRY.

1. The art of **carpentry** consists of the theoretical and practical knowledge necessary to properly execute all classes of structural work composed of wood.

2. The province of carpentry is a most extensive one, and the subject is generally qualified by prefixing a term denoting the class or character of the carpentry implied; thus, we have house carpentry, bridge carpentry, and ship carpentry. Wagon making, carriage making, car building, etc. also partake of the principles and practice of the same trade.

3. The instruction in this course will be limited to that of **house carpentry**, and it will include the essential features which define the anatomy of construction of which all classes of buildings are more or less composed, except those classified as *fireproof structures*, in which the members are made of iron or steel.

4. The carpenter is distinguished from the joiner in that his efforts are directed towards the formation and disposition of the "bones," or constituent parts, of the "skeleton" of the building, or to such parts as have reference to structure only. His operations all tend towards the stability and efficiency of the framework of the edifice, while those of the

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joiner tend towards clothing or encompassing the framework with finished woodwork, so as to render the building more agreeable and habitable.

The joiner does not commence his labors until the framework has been completed; therefore, it will be seen that the strength and vitality of the building largely depends on the effective character of its carpentry; the work of the joiner may be entirely removed, and yet the structure would remain intact, so far as the anatomy of its form and arrangement would be concerned.

5. The art of carpentry comprises three divisions, each of which is incorporated in a successful structure, namely, *analytic*, *descriptive*, and *constructive*.

The first and second divisions are contained in the *theory*, while the third constitutes the *practice* of carpentry. The first includes the analysis of the forces which generate the stresses in the framework, which is demonstrated by the *laws of mechanics*, and the disposition of the material for efficient resistance, which is regulated by a knowledge of the *strength of materials*.

The second defines the lines and methods deduced by geometric rules for laying out the work; while the third comprises the manual operations of cutting, framing, arranging, and uniting the various timbers which constitute the structure.

TIMBER.

PROPERTIES OF TIMBER.

6. A general knowledge of the properties and kinds of timber, the laws of growth and development, the characteristics of good timber, its natural defects, its conversion into building material, its shrinkage during the process of drying, modes of drying, etc. should be possessed by the student, in order to enable him to intelligently judge of the value of the material which he handles, and to provide for its disposition

and arrangement so as to secure the most stable and permanent construction.

7. To suit the purposes of the carpenter and joiner, the tree should not be cut until it has reached the period of mature growth; soon after this growth is reached, the heart begins to decay, hence the necessity of cutting, or *felling*, as it is called, at the proper time. After felling, the trunk and the larger branches are cut into suitable lengths, in which condition it is classified as *timber*, but when cut up into planks, etc. it is generally called *lumber*.

8. There are three divisions of trees, each being classified in accordance with its respective mode of growth: (1) The **exogenous**, or outward growers, in which the stem increases by the formation of annual layers deposited around the *outside* of the preceding layer; such as oak, chestnut, pine, hemlock, etc. (2) The **endogenous**, or inward growers, in which the woody matter is formed on the *inside* of the stem, of which the palmetto tree is an example. (3) The **acrogenous**, or summit growers, in which the stem is produced by the lower stalks of the leaves growing together, such as tree ferns.

9. The first division, or the *exogenous* method of development, is the one that furnishes the timber for the wood-worker. On examining the section of a young oak tree, such as shown in Fig. 1, which is a microscopic enlargement of a section of a stem of 3 years' growth, we find three well defined kinds of tissue forming it; the pith, the woody layers, and the bark. At the core, or heart, at *a*, is seen the *medulla*, or pith, composed of cellular tissue, a

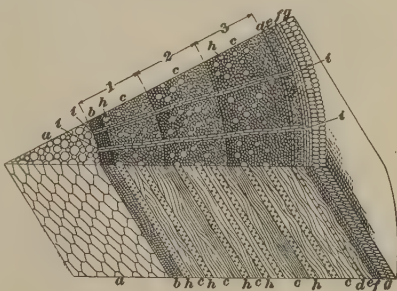


FIG. 1.

net-like fabric of cells, resembling a honeycomb; at *b*, the *medullary sheath* surrounds the pith and is composed of spiral vessels and fiber ducts for the conveyance of the sap; this constitutes the inner layer of the first year's growth; at *c* are the *wood cells*, or fiber tubes, composing the successive annual layers which are formed in a series of concentric rings; each annual layer is called a *zone*, or circular belt, as shown in Fig. 1, at 1, 2, and 3.

10. Observe that there is a well defined line of separation between each pair of zones; about one-half of the width of the zone is occupied by bundles of fiber tubes containing large sap vessels *h, h*, whose walls are pitted and dotted as shown, while the remainder of the width is filled with fiber tubes of much closer texture. In ash, chestnut, and oak, the vessels *h, h* are easily observed.

The line of separation is caused by the suspension of the growth of the stem during the winter. When the tree is young, the tissue is open and spongy, and filled with various fluids, but in process of time, it becomes thickened and firm and the ducts close, the thickening of the tissue commencing with the first formed layer. For this reason the best timber is secured from mature trees, the fibers have become compact and firm, and when once well seasoned, are less sensitive to changes of temperature. Both young and second-growth timber are unfit for all purposes where strength, durability, and "staying" qualities are concerned, the last named quality being a most essential one to the carpenter and the joiner.

11. Much difference as to strength and appearance exists between the mature, compact, inner layers of the heart wood, called *duramen*, and the outer layers of the sap wood, called *albumen*. In the former, the fibers are firm and dense and possess a deep rich color, while in the latter the fibers are open, porous, and filled with sap and usually of a pale color. The sap wood possesses little strength, and the sap it contains is largely composed of a sugary substance which invites the attack of insects and hastens decay.

12. The age of a tree may be ascertained by counting the zones, when these are visible, but various causes occur which interrupt the growth, such as severe frosts, etc., causing a line of separation, and several lines may thus be formed in one year, which may lead to an erroneous estimate.

That part of the tree which is more fully exposed to the sun will be found to have wider layers than the other part; hence, the pith, or heart, is seldom in the center of the stem.

Soft woods usually possess wider zones than the hard woods, and it will be observed that much difference exists between the width of the zones in the same tree.

As in the animal kingdom, there are three periods of existence, infancy and youth, vigorous life, and declining vitality and decay; so a similar series exists in the vegetable kingdom.

When the tree is most vigorous, it produces the largest zones. In the case of the oak, this occurs between the twentieth and the thirtieth year, after which its productive power is gradually lessened, and as it grows older, the zones become smaller.

13. Between the inside of the bark and the woody layers is located the *cambium layer*, as shown at *dd*, Fig. 1, which consists of a cellular tissue like the pith, but contains, in addition to the cell sap, the rich life-giving secretion called *protoplasm*, without which the tree cannot live. This layer possesses the property of building up the woody formation by the product of ever increasing cells, and only by the vital energy of this layer, also called the *thickening zone*, can the tree increase in diameter.

14. The bark consists of three distinct layers. The inner or *bast layer ee* is composed of woody fibers combined with a cellular tissue, which retains a flexible, rubber-like elasticity and allows it to expand as the woody layers are produced by the cambium. The central layer

ff is comprised of prismatic cells and tubes filled with juices, while the outer layer *gg* is composed of a corky substance of cellular structure. During the growth of the tree there is a continual distending and separating of the fiber and cellular tissue composing the bark, which is renewed and strengthened by means of the cambium layer.

15. In the stem of several trees, especially the oak and the locust, we observe lines which radiate from the center of the tree; these are called medullary rays. When they connect the pith to the bark, as at *ii*, in Fig. 1, they are called *primary rays*; but where they extend through only a portion of the stem they are called *secondary rays*.

These medullary rays, generally called *silver grain*, when exposed on the surface of the cut lumber, consist of a series of vertical plates or sheets. Originally of cellular tissue, they have become flattened by compression until they resemble sheets of mica; they are not, however, continuous vertically, but are buckled and present a serpentine outline, when exposed on the edge as shown in Fig. 2. On the end-cut of the figure, the medullary rays are marked *a, a*, while the porous fibers of the zones are marked *b, b*, and the close or denser ones are marked *c, c*.

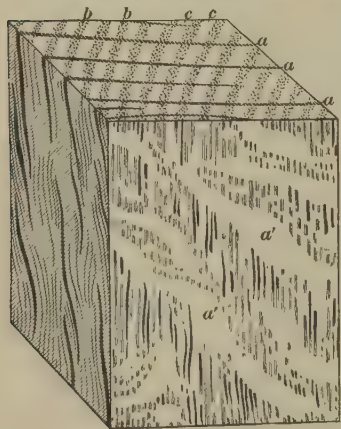


FIG. 2.

the close or denser ones are marked *c, c*.

The appearance of the silver grain, or medullary plate, when cut nearly parallel to its direction is shown at *a', a'*; it is the presence of these medullary rays which gives so much beauty to quartered oak. The rays are prominent also in

beech and sycamore, but are not so well defined in birch, chestnut, and maple.

16. The structure of the stem, as it presents itself to the observer on examining the end of an oak or ash tree of 13 years' growth, is shown in Fig. 3, in which the porous fibers or sap vessels of the coarser texture are shown at *a, a*; the closer texture at *b, b*; the primary medullary rays at *i, i*, and the secondary ones at *j, j*; the zone of the bark being shown at *c, c*. In a temperate climate the process of growth may be thus described: In the spring,

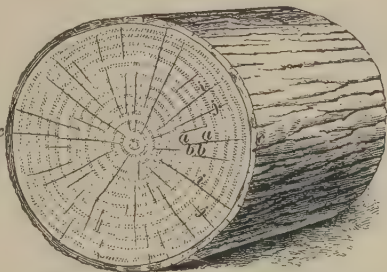


FIG. 3.

the roots extract the juices (generally called *crude sap*) requisite for vegetable growth from the earth; the crude sap circulates from cell to cell and through the fiber tubes, and ascends and forms the leaves.

At the upper surface of the leaves, under the influence of light, chemical changes take place, the sap absorbing carbon from the air and becoming denser. After the leaves are fully developed, there is no further growth until the autumn, when the so called *elaborated sap* descends by the under side of the leaves, enters the branches and stem, and continues its descent principally between the wood and the bark, where, by the action of the cambium cells, it builds up a new woody layer or zone for that year, a portion being absorbed by the bark for its nourishment.

During this period the leaves fall off, and when the sap has ceased to circulate, the growth of the tree is suspended. In tropical climates, the circulation of the sap ceases during the dry season.

17. Midsummer and midwinter in temperate climates, and the dry period in tropical climates, are considered to be

the best seasons for felling the trees; in both cases it is the time when the sap has ceased to circulate.

18. For building purposes, the trees should not be felled until they have attained their mature growth, as already stated; nor should they be used after the tree has exhibited signs of declining vitality. The greatest number of trees arrive at maturity between 50 and 100 years, and commence to decline after 150 or 200 years. When the top of the tree ceases to send forth its full complement of leaves in the spring and bare branches remain, making it appear "stag-headed," it clearly shows a lack of nutritive power, and is a sure sign that it has begun to lose its strength and vitality. The timber then loses its elasticity and firmness and gradually becomes crisp and brittle.

19. Trees growing in the heart of the forest are generally straight and tall, as it is necessary for their leaves to receive sunlight and air sufficient for vitalizing the sap; the lower branches of these trees only last a few years, when they die and fall off. On the edges of the forest, the lower branches of the trees remain alive and active, so that timber cut from such places is knotty and cross-grained, while that cut from the inside trees is clear and straight grained.

20. Where streams are available, the logs are hauled or drawn to them, and floated to the mill; this immersion in the running stream makes the sap more soluble, and tends to make it more responsive to evaporation, during the process of seasoning; but if long immersed, the fiber loses its virtue and elasticity. To save the cost of hauling the waste material, portable engines and saws are frequently transported to the place where the logs are cut.

21. When the lumber is reduced from the dimensions originally cut from the log, it is said to be *resawed*. After lumber is planed at the mill, it is called *dressed* lumber, and is assorted into many grades.

The regular thickness of dressed lumber is $\frac{5}{8}$, $\frac{7}{8}$, $1\frac{1}{8}$, $1\frac{3}{8}$, and $1\frac{7}{8}$ inches, the thickness of the rough sawed material being $\frac{1}{8}$ inch greater than these measurements.

Where $\frac{1}{2}$ -inch dressed material is required, it is usually made by resawing $1\frac{1}{4}$ -inch boards.

22. In the body of sound, healthy trees there often occur circular seams, or cracks, where the layers have become separated from each other; these are said to be caused by the action of violent wind storms upon the stem of the tree during the formation of the woody layers, and are called *cup shakes*. They generally occur near the base of the stem, and in some cases can be detected in the standing timber by an abnormal increase in the bulk of the stem.

Where they occur, as at *a, a*, Fig. 4, there is much waste in cutting the material; where the shake is short, as at *b*, the loss is not great. Sometimes circular bands occur in the stem, in which the wood is of a softer and more spongy character than the surrounding layers, and which, in some cases, show signs of incipient decay. This condition is assumed to be caused by the action of sharp frosts upon the rising sap in the newly formed layers. When timber presents this appearance, it should be immediately rejected, as it will be short lived and will soon decay.

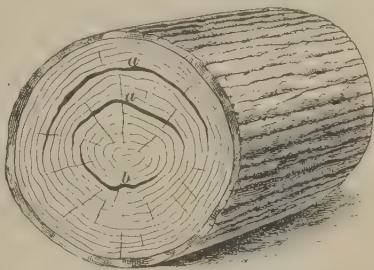


FIG. 4.

23. The soil in which timber is grown exercises an important influence upon its quality; where damp and marshy, the fiber is of a light, spongy character, the excess of water preventing the healthy action of the sap in forming firm and compact wood. Such soil is better adapted to the growth of light woods, as basswood, willow, and white-wood.

The hard woods thrive best on dry, clayey soils, while those of the pine group are best developed in sandy soils.

24. Exposure to prevalent wind storms in one direction tends to produce a twisted, spiral mode of growth. Timber possessing this character is of little value for building purposes, because, when cut into planks or scantlings, the fibers run obliquely across them, and, therefore, it possesses little strength.

25. Trees are subject to excrescences and tumors which deteriorate the value of the timber. These may result from the defective nature of the soil, the attacks of animals by gnawing, or by insects which bore into the fiber.

An excess of sap in some parts of the tree shows on the outer surface by the formation of pus, or matter, which expends the virtue of the sap and deteriorates the value of the surrounding fiber. This disease may spread, and ultimately cause the death of the tree. Trees are also affected by a brownish *rust*, which is caused by rain water obtaining access to the cambium layers by means of clefts or rifts in the bark, and which, changing the character of the sap, reduces the wood to a powder.

These clefts in the bark may be the result of an unusually dry season and a rapid rising of the temperature, causing strains greater than the bark can resist; or they may be caused by severe frosts, which, acting on the sap, cause it to expand and rend the bark.

Frequently the clefts penetrate the sap wood also, and extend into the perfect woody layers. Though these separations of the fibers may be healed up by subsequent growth, they still cause a deterioration of the wood adjacent to them.

26. There is a species of insects which deposit their eggs in the clefts of the bark, where they are hatched. These insects are a kind of beetle, and, like the moth and butterfly, pass through a larval and pupal stage of development.

The *larva*, or grub, which is hatched from this egg, immediately bores into the sap wood, which furnishes its food.

The juices of the sap wood are composed of various substances—acids, albuminoids, gums, sugar, starch, oils, and water—on which the grub feeds and thrives, until it reaches its full size, when it weaves a *chrysalis*, or envelope-like sheath, and enters the *pupa* stage. This is a state of rest, in which the grub exists without nutriment while its organization is being elaborated, when it rends the envelope and emerges a perfect insect.

As the larval period extends for months, and sometimes years, during which the grub steadily eats its way into the fiber, it will be seen how destructive the operations of an innumerable army of these workers are, when once they obtain an opportunity to attack the timber.

Were it not for the warfare waged on these herbivorous insects by birds, squirrels, lizards, etc., which eagerly devour them, and for the action of frosts and rains, tending to prevent their excessive development, few trees would reach a state of maturity and be able to furnish sound, solid timber.

Where timber has been attacked by insects, the part affected, as well as the adjacent fiber, is rendered entirely useless for building purposes.

Where the stem of a tree is regularly formed, and shows a perfect bark, free from rifts and excrescences, it may be assumed that it will produce perfect timber.

27. In order to keep the timber perfect, however, the greatest care must be exercised in piling the timber, so as to prevent the attack of parasitic plants, called *fungi*. These constitute a lower order of plant life, which, instead of independently assimilating and digesting nourishment extracted from the soil, derive their nutriment from the organic substance of others.

The fungi are developed from *spores*, or life germs, which insinuate themselves into cracks and crevices, and propagate very rapidly. The vegetative system of these plants consists of *filiform*, or thread-like tubes, which form the roots and extract their food from the substance of the timber.

The interwoven tangle of these root hairs forms what is

called the *mycelium*, which may retain the thread-like appearance of the roots, when it is defined as *filamented*; it may become so closely woven as to appear like a sheet of paper, when it is called *membranous*; or when it presents an appearance like moss, with stems and branches, in which the fibers have become firm and hard, it is called *fibrous*.

As the mycelium grows and reaches maturity it sends out thread-like shoots of closer texture than the roots, and these shoots produce the spore cases which envelope the germinal seed.

The conditions which are considered favorable to the reception and germination of the spores of the fungi, are warmth, moisture, the exemption of sunlight, and the presence of elements suited for their nutrition.

The substance of the timber is attacked by the mycelium either by robbing it of the valuable juices contained in its fiber ducts, reducing the texture to a dry, lifeless, sponge-like condition, or by secreting peculiar juices which act on the woody tissue and convert it again into *cellulose* (the starchy substance of its original formation), and which is dissolved and absorbed by the parasite, thus breaking down or decomposing the fiber, and resulting in what is known as *decay* or *rot*.

The conditions being favorable, the work of this insidious foe continues until the entire fabric is reduced to powder. The parasite attacks the living tree as well as cut timber, and in both cases the results are the same.

28. Timber should be piled in high and dry locations only, and should be kept well up from the ground on staging and strips placed between the beams or boards, so as to allow of a thorough circulation of air around every side of the timber.

No vegetation should be allowed to grow under or around the pile, as it would create conditions favorable for the retention and germination of the spores of the fungi.

The surface of the ground should be covered with ashes or gravel, which will prevent vegetable growth and also keep the surface free from moisture.

Timber deteriorates very rapidly in quality if it becomes heated, which may arise from the material being closely piled together or from being placed in a confined situation; in either case the sap is prevented from evaporating and soon begins to ferment, and causes the fiber to show signs of decay.

The decomposition of the fiber is also caused by alternate dampness and dryness, and is forcibly illustrated by the action on fence posts, which, although sound above and below the ground line, soon give way at the parts thus affected.

29. Wounds, caused by the branches of the trees being broken off close to their roots in the stem, often result in the rotting of the knots, as well as the surrounding fibers. This rotting is caused by the decomposition of the sap which accumulates and covers the wounds, and the *knots*, as the roots of the branches are called, assume a spongy appearance, which is called *druxy*. When the *druxy* knots are of a brown, fox-like color, the rot usually penetrates farther into the timber and is more likely to seriously affect the healthy wood.

30. In selecting timber for building purposes, the principal points which should be carefully observed, are straight grain, freedom from large or loose knots, wind and heart shakes, and the presence of the characteristics which indicate any of the diseases and imperfections of the fiber previously described. When cut, the sawdust should not be clammy or dough-like, but granular, or meal-like, crisp, sparkling, and free from stringy fibers. The surface of the sawed material should be clean and lustrous, presenting a firm and bright appearance, and free from spongy or woolly fibers, which indicate lack of vitality. The heart wood should be sound and mature, and the sap wood, or layers next to the bark, should be entirely removed. The wood should appear uniform in texture, and when cut should smell sweet; a disagreeable smell is a sign of decay. When the wood is planed, it should have a silky, shining surface; the shavings should come off like ribbons and stand twisting around the fingers.

When the surface appears dull and chalky, and the shavings are brittle and short, it may be considered that the stock lacks much of the virtue it ought to possess. Good material should be uniform in color; when blotchy or discolored, it signifies a diseased condition, which may be due to defective development, or be caused by piling the lumber close together after it has been sawed. The black and blue streaks and patches, which often occur in lumber, are the result of close piling, which causes the sap to sour or ferment. The defective pieces should be cut out and only such portions as appear sound and perfect should be used in work where strength and durability are essential requirements.

31. Heart shakes, sometimes called star shakes, are rifts, or cracks, which radiate from the center of the tree, as shown at *a, a*, Fig. 5. They are common in nearly all

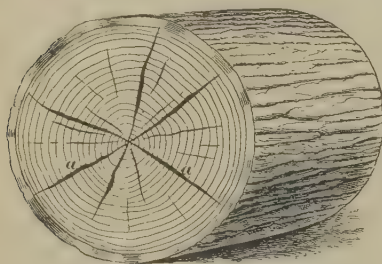


FIG. 5.

classes of timber, and are caused by the shrinkage of the layers, incidental to loss of vitality; after the period of maturity has been passed and decline has begun, the outer rings being more active, derive their nutriment by

absorbing the juices from the heart wood, thus causing a gradual but sure loss of its strength and virtue.

32. In converting timber into such sizes as are required for constructive purposes, there are several conditions governing the operation, which, if not understood, or if ignored, result in a loss of material, as well as affect the future conduct of the several pieces cut from the log.

It is seldom that the carpenter is required to use the timber in the round form given to it by nature, unless it is in the construction of rough and rustic work. Round timbers are also used in constructing pile foundations, and for props and supports when shoring buildings—the term *shoring*

signifying a temporary disposition of timbers to afford support and rigidity to any mass or structure, but, specifically, where alterations of original conditions are being effected. They are also used for scaffolding purposes, in which both the vertical and the horizontal portions are lashed together by means of ropes.

Where stock of variable widths, but of equal thickness, is desired, the log would be converted into planks, as shown in Fig. 6, by a series of saw cuts, as *ab*, *cd*, *ef*, etc., parallel to each other, the edges of the planks being afterwards squared by cutting off the *waney* or beveled portions, which formed the curved surface of the tree.

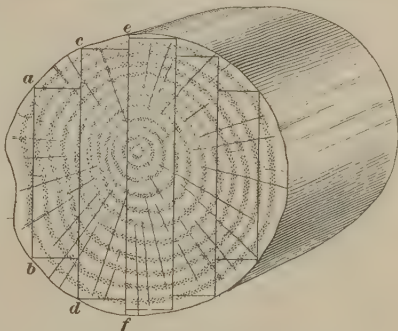


FIG. 6.

Where a large number of planks of uniform width is required, the end of the log would be marked, and cut on the line shown in Fig. 7, the portions *a, a*, called slabs, being waste material, although sometimes used for building fences, and for siding on rustic cottages, etc.

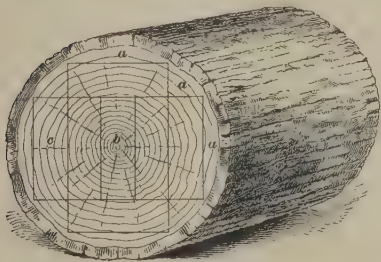


FIG. 7.

33. The manner in which the annual rings of growth are disposed on the end section of the plank, has a great influence on its behavior, after

having been cut from the log. During the process of *seasoning* the lumber, or the drying and hardening of its fibers by the evaporation of the natural sap, there is an ever prevalent tendency for the boards or planks to curl and warp,

particularly, if the process is too rapidly enforced and special care is not taken to pile the material so as to allow free circulation of air, and at the same time have it stacked so that its weight will help to keep the boards flat.

34. The cause of this tendency to curl will be understood by reference to Fig. 8, in which is shown the end sections of two boards

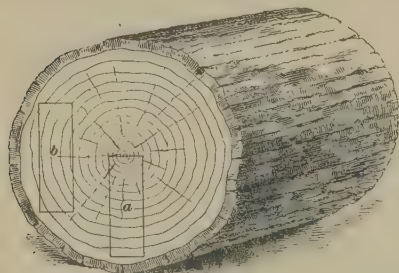


FIG. 8.

cut from different portions of the tree. At *a* it will be observed that the annual rings are nearly at right angles to the surfaces of the board, while at *b* they cross the surfaces obliquely and become nearly parallel

to the faces. After the boards have been cut and have commenced to dry, owing to the evaporation of the sap, the sap ducts and fibers begin to contract and shrink; the form taken by the board in shrinking will be governed by the length of the annual rings on the section. In *a* the rings are practically of the same length, and the medullary rays being nearly parallel to the surface of the board, the faces will remain straight and true across their width, while in *b* the inner ring is shorter than the outer one; hence, the outer one will shrink more, causing the surface farthest from the heart of the tree to assume a concave form. This effect is further increased by the fact that the nearer the heart, the more dense and mature is the fiber, so that portions cut adjacent to it shrink less than those which are farther from it. Where a tree is twisted in its growth—that is, where the fibers seem to twist spirally around the stem in the height—it is impossible to cut boards from it which will not warp and wind, not only while they are seasoning, but also whenever affected by changes in temperature.

35. As has been shown, boards having the annual rings disposed as at *a*, are less liable to shrinkage and curling, and if the timber is rich in medullary rays, the element of beauty is also enhanced; furthermore, such boards, having only the edges of the laminations exposed, wear better and more evenly than where the leaf-like figure of the grain is shown on the surface, as it would be in the case of the board *b*.

METHODS OF SAWING.

36. In order to obtain as many boards as possible from the tree, which possess the many merits arising from this disposition of the rings on the end section, a method of first cutting the logs into quarters, and then reducing them to the required sizes, is adopted.

This method is shown in Fig. 9, where *ab* and *cd* are lines showing the first saw cuts which divide the log into four quarters, *ac*, *cb*, *bd*, and *da*, each of which is then sawed into plank by some one of the methods shown, according to the purpose for which the lumber is intended and the economy of the material, which it is necessary to observe.

The quarter, sawed as shown from *a* to *c*, gives by far the best

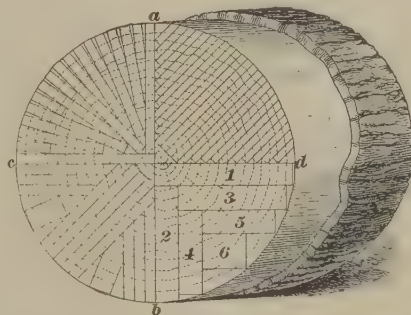


FIG. 9.

results, as the annual rings cross the plank nearly at right angles to its face, and the medullary rays being parallel to this face will exhibit the lines of the silver grain, so sought and admired in quartered oak. But it is not economical in material, and requires more time and attention to divide it, than does any of the other methods.

The waste of material is over twenty-five per cent., and, though this waste can often be utilized, it is usually counted

as loss in estimating the amount of timber which can be cut from a log. The time required to reduce this quarter to plank is thirty per cent. more than is required to reduce the quarter *cb*, and fifty per cent. more than the quarter *da*. Therefore wood quartered in this manner is expensive, and its use is confined almost exclusively to furniture and fine cabinet work.

The method used in sawing the quarter from *c* to *b* is, as above shown, much more economical in time, though the waste of material is about the same. These waste pieces, however, are much larger and fewer than in the former case and can usually be utilized to better advantage. This is the usual method of cutting hardwood logs, and lumber produced by this method is used for all ordinary high-grade work in carpentry and joinery, especial attention being given to the position each plank occupied in the original log, according to the purpose for which it is required.

The method of sawing shown from *a* to *d* can hardly be called *quartering* in the sense we consider the results of that term. It is somewhat of an improvement on the method of bastard sawing, shown in Fig. 6, but there is but one-fifth of the finished lumber that presents the advantages of beauty and durability secured by either of the two former methods of sawing, and this fifth is generally selected by the dealers, and classed with the plank produced by the middle cut of the section from *c* to *b*. The other four-fifths is used almost entirely in cheap furniture and for the interior finish and trim of houses, where the terms *oak floors* and *hardwood trim* sound very well in the description, but refer to details which would give better service and be more in keeping with the character of the building, if constructed of the less aristocratic sounding pine or spruce, which had been reduced from a properly sawed log.

The method shown at *bd* is for securing large pieces, and the heavy planks are cut in the order their end sections are numbered. Numbers 1 and 2 are the choice pieces, and should always be selected for floorbeams, where a long span demands a beam that is not liable to warp or twist.

The selection of certain cuts for particular purposes, will be considered when those purposes are taken up for discussion, and attention is here again called to the careful study of Figs. 6, 7, 8, and 9, as illustrating the influence which the original position of a stick of timber in the tree has upon its subsequent behavior.

SEASONING.

37. The process of evaporating the sap, or the drying out of lumber, is effected after it has been sawed into planks, joists, studs, etc., and two methods known respectively as **seasoning** and **kiln-drying** are recognized as suitable and efficient for the purpose.

In the first of these, the boards are placed in the open air in large square piles, with narrow strips between the layers; a free circulation thus takes place throughout each pile, and the lumber remains in this position from two to four years, according to its ultimate purpose—two years being considered adequate for joists, studs, sheathing, and other ordinary framing material, while work intended for trim, doors, sashes, and other products of the joiner's skill, should season for four years, or even more, according to the class of material.

Kiln-drying is effected by piling the lumber, as above described, in chambers, or kilns, within which a circulation of air is maintained at a temperature of about 140° F. and at a speed of about 40 miles per hour. Vacuum pumps are used to produce this rapid circulation and to remove the moisture as it evaporates from the boards.

In this manner, lumber not over 2 inches in thickness can be thoroughly dried in about forty-eight hours, which is certainly a great saving of time, but the result is acquired at the expense of a loss of vitality of the material.

38. Kiln-dried lumber lacks the toughness and elasticity retained in the seasoned material, has a greater affinity for atmospheric moisture, and is often subject, especially in the softer woods, to what is known as *dry shrinkage*—that is, a

shrinkage caused by the gradual closing together of the cell walls from which the moisture was evaporated in the kiln, leaving the cell in a vacuous, or hollow, condition. This *dry shrinkage* does not take place until after the material has been worked, and regardless of the position of the zones, or annual rings, the wood becomes concave on its freshly cut surface.

The cause of this is that the outside, or surface, tissue of the material is dried first, and thus forms a sort of casing, or crust, which holds the inner fibers in position, and when this surface is removed through the agency of the saw or plane, the interior fibers, being thus relieved of their protecting casing, gradually close on the exposed side and cause the wood to bend, or warp.

This will also occur in weather-seasoned wood which has been placed in one position for a long period and remained uncut or unworked. Thus, the top of an old table will almost invariably become concave if it is planed off to get a new surface.

39. Good results are obtained by the process of subjecting weather-seasoned boards of two or three years' exposure to the kiln-drying process before they are used in a building, or immediately after they are worked into flooring, siding, ceiling, etc. Boards thus treated and kept perfectly dry thereafter can be used in the trim and finish of a building, and if primed and painted, or filled and varnished as soon as possible after they are in place, a good, durable, and unchanging job can be assured.

PROPERTIES OF DIFFERENT KINDS OF WOOD.

40. Wood, as a building material, is divided into three general groups, namely, the *evergreen* class, the *tropical* class, and the *hardwoods*.

In the first of these are classed the pine, spruce, hemlock, cedar, cypress, etc. The tropical woods include palm, rattan, bamboo, etc. The hardwoods are oak, chestnut,

walnut, locust, maple, hickory, ash, boxwood, whitewood, and a number of others.

Each of these woods has peculiarities and characteristics which render it fit and useful for some building purposes, and utterly unfit and useless for others.

THE EVERGREEN CLASS.

41. White pine, commonly known as *pine*, or sometimes referred to as *northern pine*, to distinguish it from the species described below, is a tree common in the northern part of the United States and in Canada. It furnishes a light, soft, and straight-grained wood of a yellowish color, but is not as strong as other woods of the same class, and in building is used, principally, as a finishing material, where a good, durable, but inexpensive job is required. As a material for patternmaking it has no equal, and its power of holding glue renders it invaluable to the cabinetmaker and joiner.

42. Georgia pine, also known as *hard pine*, *pitch pine*, and occasionally as **long-leaved pine**, which is, in reality, the best name for it, is a large forest tree growing along the southern coast of the United States, from Virginia to Texas, and extending only about 150 miles inland. Its annual rings are smaller than those of the white pine, and have a dense, dark colored and resinous summer growth, which gives the wood a well marked grain.

The wood is heavy, hard, strong, and, under proper conditions, very durable. For heavy framing timbers and floors it is most desirable, and on account of its grain is sometimes used for the trim of unimportant rooms. It rapidly decays in a damp location, and, therefore, cannot be used for house sills, or as sleepers or posts which are in contact with the ground, but if situated in a dry, well ventilated place, it will remain practically unchanged for over a century.

Great care should always be exercised in specifying work to be done with Georgia pine, as in many localities this wood is confused with another material variously known as

Carolina pine, *yellow* pine, and *southern* pine, which is greatly inferior to it in every respect.

The *Carolina* pine is not a *long-leaved* pine at all, and is neither as strong nor as durable as the *Georgia* pine. In appearance it is somewhat lighter than the long-leaved pine, and the fiber is softer and contains less resin than the regular *hard*, or *pitch*, pine.

43. *Spruce* is a name given to all the wood furnished by the various species of the *spruce fir tree*. There are four varieties of the wood, known as *black spruce*, *white spruce*, *Norway spruce*, and *single spruce*. *Black spruce* grows in the northern half of the United States and throughout British America. Its wood is light in weight, reddish in color, and though easy to work, is very tough in fiber and highly desirable for joists, studs, and general framing timber. It is also greatly used for piles and submerged cribs and cofferdams, as it not only preserves well under water, but also resists the destructive action of parasitic crustacea, such as barnacles and mussels, longer than any other similar wood.

44. *White spruce* is not so common as the above described variety, though when sawed up into lumber it can scarcely be distinguished from it. Its growth is confined to the extreme northern part of the United States and to British America.

Norway spruce is a variety growing in central and northern Europe and in northern Asia, and its tough, straight grain makes it an excellent material for ships, masts, spars, etc., as well as the more ordinary purposes of house building.

Under the name of *white deal* it fills the same place in the European woodworking shops as white pine does in America.

Single spruce grows in the central and the western part of the United States. It is lighter in color, but otherwise its properties are similar to the black and the white spruce.

45. *Hemlock* is similar to spruce in appearance, though much inferior as a building material. The wood is very brittle, splits easily, and is very liable to be *shaky*. Its grain is coarse and uneven, and though it holds nails much more

firmly than does pine, the wood is generally soft and not durable.

Some varieties of it are better than others, but in commerce they are so mixed that it is difficult to obtain a large quantity of even quality. Hemlock is used almost exclusively as a cheap, rough-framing timber.

46. White cedar is a soft, light, fine-grained, and very durable wood, but lacks both strength and toughness. Its durability makes it a desirable material for shingles, and also for tanks in which water is stored, and these are about the only purposes for which it is used in house building, though it is used largely for other purposes, such as boat-building, cigar-box manufacture, and cooperage.

47. Red cedar is a smaller tree than white cedar, and of much slower growth. The wood is very similar in texture to white cedar, but even more compact and durable. It is of a reddish-brown color, and possesses a strong, pungent odor, which repels insects. Its extreme durability makes it valuable for posts, sills, sleepers, etc., in contact with the ground, and its strong odor renders it extremely serviceable as shelving for closets, and linings for chests and trunks, when the exclusion of moths and other insects is desired.

48. Cypress is a wood very similar to cedar, which grows in southern Europe and in the southern and western portions of the United States. It is one of the most durable woods, and is well adapted for outside use.

In the northern part of the United States its use is confined, almost exclusively, to shingles, but in the South it is used as extensively as pine is in the North.

49. Redwood is the name given to one of the species of giant trees of California, and is the most valuable timber grown in that state. It grows to a height of from 200 to 300 feet, and its trunk is bare and branchless for one-third of its altitude. The color is a dull red, and while the wood resembles pine, and is used generally in the West for the same purposes as pine is in the East, it is inferior to pine, on

account of its peculiarity of *shrinking lengthwise* as well as crosswise. It is used largely for railroad ties, fence posts, telegraph poles, and other purposes where durability under exposure is required. As an interior finishing material it is highly prized, as it takes a high polish, and its color improves with age.

THE HARDWOOD CLASS.

50. The **hardwood** group is headed by the **oak** as typical of its class, nearly all others being compared with it in regard to hardness, durability, and strength.

51. *White oak* is the hardest of the several American species of the oak tree, and it grows in abundance throughout the eastern half of the United States. It furnishes a wood which is heavy, hard, cross-grained, strong, and of a light yellowish-brown color. It is used where great strength and durability are required, as in framed structures, ship building, cooperage, and carriage making.

Red oak is similar in nearly every respect to white oak, except in its grain and color, the grain being finer and closer and the color darker and redder. It is also about 12 per cent. softer.

English oak is similar to the American oaks in color, texture, and appearance, but is superior to them for such structural purposes as ship building and house framing.

The structure of the fiber, and the large, thick, and numerous medullary rays, make oak especially prized as a material for cabinet work and furniture, when the log is *quarter-sawed*. The silver grain and the high and durable polish which the wood is capable of receiving, make it one of the most beautiful used in joinery and cabinetwork.

52. **Ash**, the wood of a large tree growing in the colder portions of the United States, is heavy, hard, and very elastic. Its grain is coarse, and its color is very similar to that of red oak, which it also resembles in strength and hardness.

Ash is used sometimes for furniture and cabinetwork,

where it is often supposed to be an imitation of oak, but it is never so strongly marked in the silver grain as oak, and its tendency, after a few years, to become decayed and brittle renders it unfit for structural work.

53. Hickory is the heaviest, hardest, toughest, and strongest of all the American woods. The medullary rays are very numerous and distinct, and produce a fine effect in the quarter-sawed plank. The flexibility of the wood, together with its toughness and strength, render it valuable in the manufacture of carriages, sleighs, and implements requiring bent-wood details.

As a building material, it is unfit for use: first, on account of its extreme hardness and difficulty of working; and second, on account of its liability to the attacks of boring insects even after the fibers have been filled and varnished.

54. Locust is one of the largest forest trees in the United States, and furnishes a wood that is as hard as white oak. It is composed of very wide annual layers, in which the vessels are few but very large, and are arranged in rows, giving the wood a peculiar striped grain.

Its principal use is in exposed places where great durability is required, while for posts for buildings and fences in damp locations it has no superior.

Its hardness increases with age, and on this account it is used for turned ornaments and occasionally in cabinetwork.

55. Black walnut is one of the finest and largest timber trees peculiar to the United States. Its wood is heavy, hard, and porous, and its dark, purplish color is marked by a beautiful wavy grain. Strong, durable, and not subject to the attacks of insects, it, at one time, furnished the most popular wood for interior decoration and fancy cabinetwork, but its present use is confined generally to small cabinetwork and gun stocks, which latter are made almost exclusively of this material.

The irregular and knotted roots of the tree produce, in the wood cut from them, an appearance called **burl**.

56. Cherry.—The wood of the *wild-cherry* tree is a moderately heavy wood, hard, and very durable. The annual rings are wide and even in their structure, while the medullary rings are fine, numerous, and of a light-red color, giving the wood a close, fine grain, of a brownish-red color, which is susceptible of an exceedingly high polish, and is, therefore, much used in cabinetwork.

The close and even grain in cherry makes it particularly adaptable to imitations of more valuable and less abundant woods.

Cherry stained black to imitate *ebony* cannot be detected from the genuine material except by scraping off the polished surface; and as a substitute for mahogany and rosewood it makes a fair imitation. For this reason it is largely used for piano cases, book shelves, furniture, and other general cabinet work which is turned out in quantity and afterwards stained to imitate various other materials.

Cherry does not respond as quickly to changes of temperature or dampness as do most other woods, for which reason, it is, in many instances, more serviceable as an imitation of ebony, mahogany, or rosewood than would be the genuine material.

57. Birch is a wood strongly resembling cherry in its texture and, in some of its species, also in its color. *Black*, or *cherry*, birch furnishes the best lumber, and most strongly resembles the cherry in color, texture, weight, and strength, but it is not as durable, and is much more affected by atmospheric influences.

White, or *paper*, birch is chiefly noted for the quality of its bark, which can be stripped from the tree in long, paper-like sheets. It was extensively used by the Indians to thatch the roofs of their huts and to construct their canoes. The wood is used principally in the manufacture of wood-pulp paper, though small turned articles, such as spools, cups, spoons, etc. are manufactured from it.

58. Maple is a large-sized timber tree, which furnishes a light-colored, fine-grained, hard, strong, and heavy wood.

The annual growth is narrow and close, but, scattered through it, small vessels may be seen on careful examination. The medullary rays are small and distinct, giving to the quarter-cut lumber a clearly defined silver grain. Two other characteristics of the grain are observed, especially in old trees, and are known as *curly maple* and *bird's-eye maple*. The former is a waviness of the grain similar to the *burl* obtained from the root timber of the walnut tree, while the bird's-eye is an effect produced in old trees by the circular inflexion of the fibers. In appearance the plank is covered with numerous small spots, similar to minute knots, and strongly resembling bird's eyes, whence it derives its name. Though both the *curly maple* and the *bird's-eye* are practically distorted fibers and materially reduce the strength of the wood, they are highly prized in the cabinetmaker's art, as they lend to the polished surface a variegation and impart a beauty equaled by few other materials.

59. Chestnut, a large forest tree common to the eastern part of the United States, produces a comparatively soft, coarse-grained wood, which, though very brittle, is exceedingly durable when exposed to the weather.

It will not stand variations of slowly evaporating moisture as well as locust, and is, therefore, not so well suited for fence posts and sills laid in contact with the earth; but for exposed structures and sleepers laid in concrete or sandy soil, it affords a material much more easily worked than locust, and nearly as durable as cedar.

At the age of 50 years the tree is in fine condition for cutting, previous to which the wood is likely to be composed of large cells filled with moisture, which do not dry out without impairing the quality of the timber. On the other hand, if the tree is not cut at 50 years, it is almost sure to become decayed in the heart wood, and thereby rendered unfit for use.

60. Butternut is a small species of walnut, whose wood is of a light color, and possesses a strongly marked grain. Its lumber can be secured only in short lengths, and though soft and easily worked with edged tools, it will not split

easily, resists moisture, and remains comparatively unaffected by heat until the wood begins to char. It is not suitable for a framing material, but is sometimes used in cabinetwork on account of its susceptibility to an extremely high polish.

61. Beech is the wood of a large forest tree growing in the eastern part of the United States, and in Europe. It is used but slightly in building, owing to its tendency to rot in damp situations, but it is often used, especially in European countries, for piles, in places where it will be constantly submerged.

It is very hard and tough, and of a close, uniform texture, which renders it a desirable material for tool handles and plane stocks, a use to which it is often put.

It is occasionally used for furniture on account of its susceptibility to a high polish, but is too brittle for very fine work requiring strength.

62. Whitewood, so called from the purity of its color, is the lumber of the tulip tree, a large, straight forest tree abundant in the United States. It is light, soft, very brittle, and shrinks excessively in drying. When thoroughly dry it will not split with the grain, and in even slight atmospheric changes will warp and twist exceedingly. Its cheapness, ease of working, and the large size of its boards cause it to be used in carpentry and joinery, in many places where it is utterly unsuited.

63. Buttonwood, also called **sycamore**, is the name given in the United States to the wood of a species of tree generally known as **plane tree**. The wood is heavy and hard, of a light brown color, and very brittle. Its grain is fine and close, but, though susceptible of a high polish, it is not much used in general carpentry or joinery, as it is very hard to work and has a strong tendency to warp and twist under variations of temperature. In damp places it will soon show signs of decay, and is, therefore, unfitted for any but the most protected positions.

64. Apple and pear trees furnish wood much used for tool handles, plane stocks, and small turned work, but neither is much used in building.

The irregular-twisted branches of the former are sometimes used in ship building, from which to saw the ribs of a boat, taking advantage of the natural bend of the wood to form the rib, but for other building purposes it is rarely used, as the lumber runs in short, irregular pieces, with a crooked and twisting grain.

Pear wood is sometimes used for carved panels in cabinet-work, on account of its yielding so easily to edged tools.

65. Boxwood does not, as its name might imply, enter in any way into the manufacture of boxes. It grows in Europe and Asia, along the coast of the Mediterranean Sea, is close-grained, yellow in color, and very desirable, on account of the absence of shrinking or warping tendencies, for small carved or turned work, such as spindles and chessmen, and is particularly useful in wood engraving, for which purpose it has no equal. As a building material it is very rarely used.

66. Basswood is the name given to the timber of the American *linden* tree. In color, texture, and general appearance, it strongly resembles pine, but is much more flexible. On this account it is sometimes used for curved panels in furniture and interior decorations, as well as in carriage manufacture for the curved surfaces of various vehicles.

It has a great tendency to warp, and will shrink both across and parallel with the grain, rendering it undesirable in building, unless strengthened by battens or a hardwood lining.

67. Mahogany is the wood of a large, handsome tree which is a native of the West Indies and Central America. Its color, grain, and hardness vary considerably according to the age of the tree and the locality of its growth.

It is a wood of great commercial value, on account of its great strength and durability. The straight-grained varieties do not warp or shrink materially with atmospheric

changes, and are used extensively as frames for fine machinery, work benches, etc.

The cross-grained species, on the contrary, warps and twists to a remarkable extent, and though highly prized as a material for panels and furniture, it can be used to advantage only when veneered upon some more reliable wood. Ordinary straight-grained mahogany is not a very hard wood, and when freshly cut, its color is a light, yellowish tan, but with age it becomes darker and exceedingly hard and brittle.

68. Rosewood is the heavy, hard, and brittle product of several trees native to the tropical countries. It has a beautiful grain, alternating in dark brown and red stripings, which, when subjected to a high polish, make the surface one of the handsomest products of the vegetable world. The solid wood is used for handles to fine tools, but for few other purposes. As a veneer, it is applied to all kinds of cabinet, furniture, and joinery work, where richness, elegance, and durability are desirable, regardless of expense.

69. Ebony, a dark, almost jet-black wood, native in the East Indies and parts of Africa, is a heavy, strong, and exceedingly hard wood, with an almost solid annual growth. It takes an exceedingly high polish, and is used mostly for small turned and cabinetwork, though its veneers are applied to interior work, and also to fine furniture. It is not used as much for general interior trim and paneling as formerly, on account of its expense, and the somber appearance that a black surface must necessarily lend to a room, and besides this, the imitation of it in stained cherry is much cheaper and so like the original that it would take an expert to detect the difference.

70. Lignum vitæ is another exceedingly heavy, hard, and dark-colored wood, with an almost solid annual growth. It is very resinous, difficult to split, and has a soapy feeling when handled.

Its color is dark brown, with lighter brown markings, and it is used mostly for small turned articles, tool handles, and the sheaves of block pulleys.

CLASSES OF FRAMED STRUCTURES.

71. Carpentry, as applied to house building, relates to the construction of the rough timber framework of the building in all its parts, from the foundation to the roof. In buildings which are partly constructed of stone or other material outside the carpenter's province, the carpenter is usually called upon to furnish, and generally to set, all centers, templets, wood lintels, etc. that may be required for arches, square openings, and angles.

72. Buildings constructed entirely of wood, above the foundations, may be divided into two general classes; viz., *braced-frame* and *balloon-frame* structures.

A **braced-frame** building is one in which each piece of the structure is carefully fitted and fastened to every other piece it comes in contact with, and the whole skeleton is thereby made stiff and secure before any of the covering material is applied.

A **balloon frame**, on the contrary, is one in which the timbers are simply nailed together; it depends, therefore, entirely upon the sheathing, or outer covering, for strength and security.

73. The former method is the one used in ancient times, and had its origin when all nails, bolts, and iron straps were made by hand, and required more labor to produce them than the cutting of mortises, or the halving of joints. With the advent of machine-cut nails came the balloon frame, which, though it may be a somewhat flimsy affair in itself, is, after the sheathing is on, much stronger and stiffer than the regular, or braced frame, and costs about half the money.

There are still, however, classes of buildings where the balloon frame is hardly suitable, and there are also instances in balloon framing where the joints require close and accurate fitting. To effect the best construction in a building, therefore, requires not only a knowledge of the kind of material best suited to the place and purpose, but also a knowledge of the proper size or sectional area of each piece,

to withstand the strain that may come upon it, and the proportions of its dimensions to give the required area and at the same time suit the position in which it is to be placed.

74. The fitting together of these several pieces of the structure demands a knowledge of the proper kind of joint required in each particular case; an understanding of the conditions likely to arise which would tend to render the joint more or less ineffectual, such as shrinkage, dry rot, or warping; and the ability to compensate or prevent any evil results which such conditions would entail.

JOINTS.

75. The simplest joint between two pieces of wood is the square butt joint shown at (a), Fig. 10, where the tim-

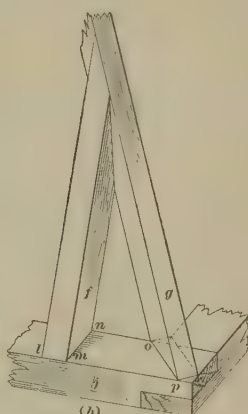


FIG. 10.

ber *b* effects a butt joint with the timber *a* on the line *kcd*. This joint, called a *barefoot* joint, is used in balloon-frame construction where the studs rest upon the sills or partition caps, and are secured in position by *toenailing*, as shown at *e*. An oblique butt joint is shown at (b), Fig. 10,

where *lmn* and *opq* are the lines of the joints between the timbers *f* and *j* and the timbers *g* and *j*. This form of the joint is sometimes used for placing rafters upon the plate, or against the ridge board, and must always be securely toenailed, or a movement in the position of the foot *lm* or *pq* would throw the joint out of alinement.

76. Mortise and Tenon.—Where greater strength and security than can be obtained from the butt joint is required, we make use of the *mortise-and-tenon joint*, shown in Fig. 11.

A rectangular hole $abcd$, called a *mortise*, is cut into one of the timbers, as w , and on the end of the other timber y is shown the projecting pin or *tenon* efg , which fits into and exactly fills the mortise.

The proportion of the width da of the mortise to the thickness of timber in which it is cut is one-third, and the mortise is cut into the center of the thickness. Or, if one timber is larger than the other, they are usually so framed that, when brought together, one face of each piece will be flush.

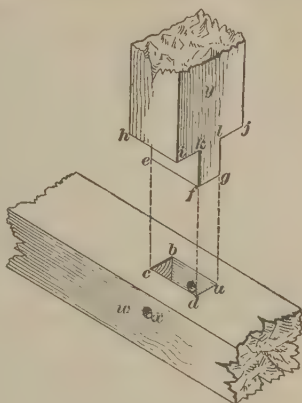


FIG. 11.

77. These mortise joints are nearly always secured in place by means of a *draw-bore pin*, which is inserted as follows: After the mortise is cut, and the tenon is accurately fitted to it, a hole is bored in the timber, squarely through both cheeks of the mortise, as shown at x , in Fig. 11. The position of the hole x is accurately marked on the tenon efg , and a hole is then bored through the tenon *but located from $\frac{1}{16}$ inch to $\frac{1}{8}$ inch nearer the shoulder* than the marks made through the hole in the mortise. When the tenon is now inserted in the mortise, the relative position of the holes will be somewhat as shown at (a) , in Fig. 12, which is an enlarged section through the girt and corner post on the line xy . A wooden pin is then driven through these holes, and by forcing them into line it brings the shoulders of the tenon p tight up against the cheeks of the mortise q , thus making the joint firm and secure, as well as free from any liability to work itself loose. This wooden pin, usually called a *trunnail* or *draw-bore pin*, should be cut from a piece of straight-

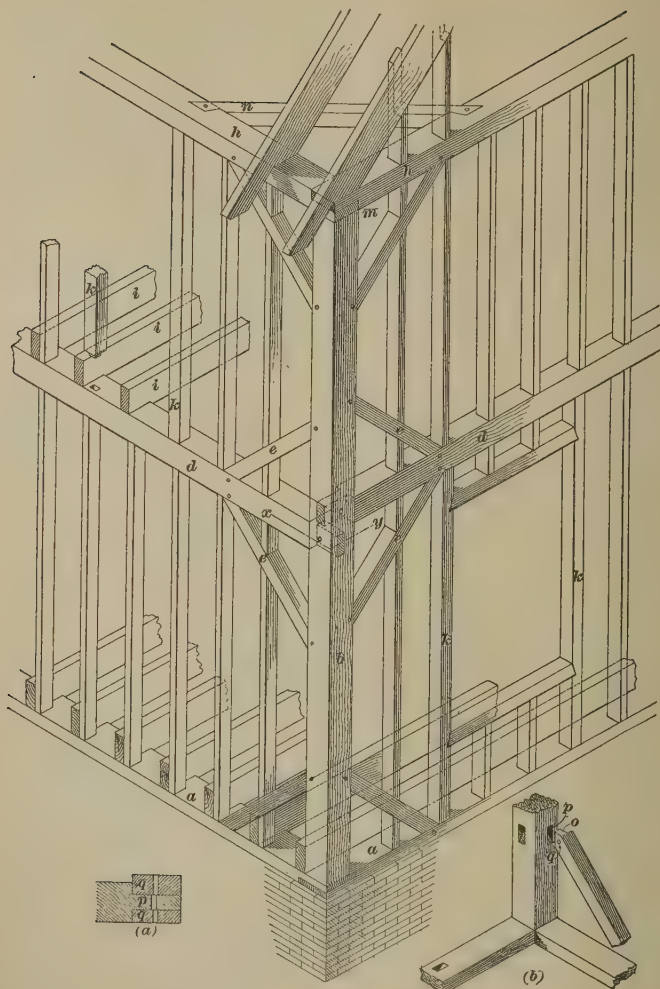


FIG. 12.

grained, tough, and durable wood, preferably locust or oak, about 1 inch to $1\frac{1}{2}$ inches square on the ends, and about 2 inches more in length than the mortised timber is in thickness.

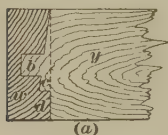
The corners are planed off, bringing it down to an octagonal shape on the ends, and its sides are then slightly tapered about one-fourth the length, so that the pin will enter the draw bore. If, through carelessness, or error in measurement, the hole in the tenon is not slightly nearer the shoulder than the hole in the mortise, the joint will not be tight, and may result in what is called a *push bore*, which is a term given to this joint when the driving of the pin loosens the pieces instead of tightening them.

78. In braced-frame construction, the mortise and tenon form the joint of nearly every two important timbers that come in contact. In Fig. 12 is shown the corner of a braced-frame building, where *b* is the corner post mortised into the sill *a* at the bottom, and into the plate *h* at the top; the girts, or interties *d*, on one of which the second tier of beams *i* rests, are mortised into the corner post, and secured with a draw-bore pin as above described, while the angle braces *e* are mortised into both the girt and the corner post. The tenons on these beams are cut somewhat differently from those on the other members, owing to the diagonal position of the timbers. At (*b*) is shown an inside view of the corner post and the joints between it and the lower braces. The top of the brace tenon *o* is cut so as to enter the corner-post mortise *p* at right angles to the face of the post; while the bottom of the tenon is in the direction of the plane of the under side of the brace, and the lower side of the mortise is cut on the same plane. The draw-bore hole in the tenon is shown at *q*, but does not show on the inside of the corner-post, as it is unnecessary to bore it all the way through. This constitutes the system of braced-frame construction, and though the studs are sometimes mortised into both sill and intertie, or into intertie and plate, they are thus joined simply to hold them in their places and not to add strength to the general frame. Double studs adjacent to openings, as shown at *k*, should always be mortised, but in modern work the small studs are simply spaced 16 inches on centers, and butt jointed to form a filling between the posts. In braced-frame

construction, where the building is over 30 feet long, it is usually necessary to provide intermediate posts in the side walls connecting the ends of the building in order to have a mortise joint at the end of each horizontal timber.

79. Mortise-and-tenon joints are used almost exclusively in modern work, for the framing of floorbeams around stair wells, chimney breasts, and other openings, as shown in Fig. 32, where *d, d* are two heavy floorbeams, called *trimmers*, spaced each on one end of the chimney breast *c*, and connected at *a* by a short piece of joist called a *header*. The beams *b* are called *tail-beams*, and each one is mortised into the header as shown by the ends of the tenons at *f*.

80. Tusk Tenons.—In Fig. 13 (*a*) is shown the tenon *b* on the tail-beam *y* let into the header *w* at its center, and



to secure additional strength a tusk *c* is cut on the tail-beam, to rest on the shoulder *d* of the header. The length of the tusk and the thickness of the tenon should each be about one-sixth the depth of the beam.

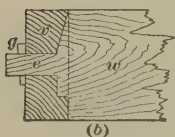


FIG. 13.

At (*b*) the tenon *e* extends entirely through the beam *v*, and is held securely in place by a wooden draw-bore pin, or wedge, as at *g*. This is the form of mortise used to secure the header to the trimmers, while the form shown at (*a*) is used to secure the tail-beams to the headers.

Where the joints are made with patent beam-hangers or stirrup irons, no mortising is necessary.

81. Stirrup irons are pieces of wrought iron, generally $\frac{3}{8}$ in. $\times$ $2\frac{1}{2}$ in., bent to form a hook over the trimmer-beam and a seat in which the header can rest, as shown at *e*, Fig. 32. The trimmer and header are usually nailed together to keep the joint close, while the stirrup iron carries the weight; for good work, however, a strap or bolt should be used to keep the trimmer and header in close contact.

82. Splice Joints.—When timbers cannot be obtained of sufficient length to form an entire sill, plate, or other

horizontal member, it is necessary to resort to some form of a *splice joint*, as shown in Figs. 14 and 15.

Fig. 14 shows a plain splice joint obtained by cutting away one-half of the thickness and width of each timber, e and d , and then fitting the remaining half of each piece into the space formerly occupied by the half cut away, as indicated by the dotted lines in Fig. 14, where the piece d is shown at right angles to the piece e , which would be its position in the corner of a building, as shown at m , Fig. 12. By turning the piece d so that its edges fg and hi would coincide with the edges op and nq of the piece e , the joint would splice the two pieces into a continuous timber, as shown at Fig. 15, although when such a condition exists, another form of the joint, known as *beveled* or *oblique splicing*, is considered preferable.

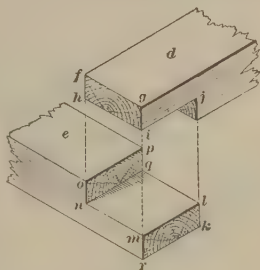


FIG. 14.

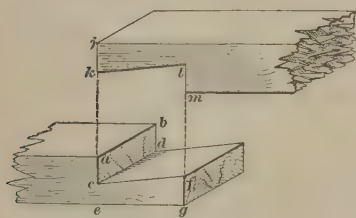


FIG. 15.

This form of splice is effected by cutting away a little more than half the thickness of the timber at $a b c d$ and $l m$, Fig. 15, and leaving a little more than half the thickness at the ends fg and jk . The formation of this joint requires great care, lest the timbers be weakened by cutting too deeply at $a c$ and $l m$, but when properly made, this joint does not pull apart as readily as the previous one.

83. Dovetail-halving is another form of joint used where prevention from sliding is a desirable condition. Fig. 16 shows two forms of this joint formed as follows: The timber m is first halved on the end, in the same manner as the timber d in Fig. 14, and the remaining half thickness is then cut to the wedge shape $a b j i$, which is called a **dovetail**. In the timber n a *dovetail mortise* $e f h g l o$ is then cut

in, half the thickness of the timber *m*, and the two pieces are then driven together and held in place by spikes or screws.

The form shown at (*a*) is best adapted to positions where timber *m* is intended to be placed at right angles to the

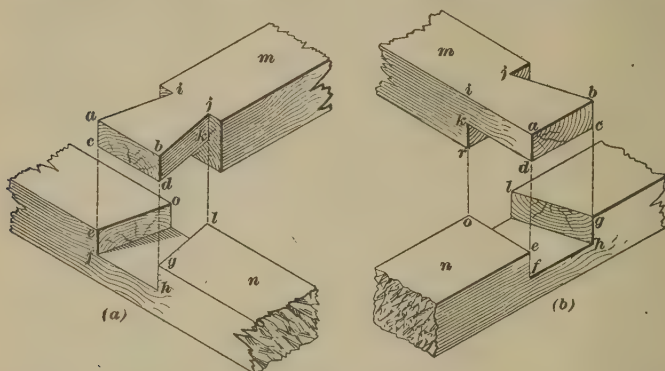


FIG. 16.

timber *n*, and although the form (*b*) is also used in similar locations, it is best adapted to locations where the timber *m* makes an acute or an obtuse angle with the timber *n*, as is shown in Fig. 12, where the timber *n* forms at the same time a tie and a brace to the two timbers *h* forming the plate.

84. A straddle, or bridge, joint, Fig. 17, is used when

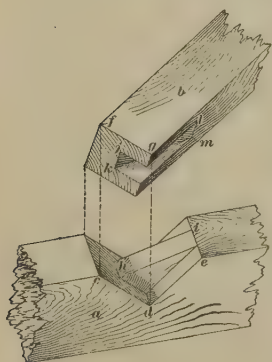


FIG. 17.

a secure footing is required for the toe of a rafter, or strut. The tie-beam *a* is notched on top, to receive the foot of the strut *b*; the side *de* of the notch is in the direction of and at the same angle as the slant of the strut, while the side *dc* is at right angles to *de*, and equal in length to the depth of the strut at *fg*. The bridge tenon *hi* is left standing when the notch *cde* is cut, and a mortise *jklm* is cut into the end of the strut to straddle it, and thus prevent it from slipping.

Another method of treating this joint is to work the tenon *hi* on the strut timber *b*, Fig. 18, and sink the mortise *jk* into the tie-beam *a*. The tie-beam *a* is then notched on the line *cd*, a distance equal to only half of the depth of the strut *b*, but is still kept at right angles to the direction of the slant of the strut, while the line *de* has a pitch varying in different cases, according to circumstances.

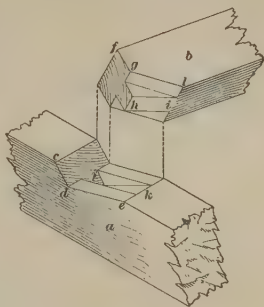


FIG. 18.

85. A method of footing the rafters on tie-beams without the mortise and tenon is shown in Fig. 19 (*a*), where the joint is similar to the one in Fig. 18 in every respect, except that the mortise and tenon are omitted.

Fig. 19 (*b*) shows a variation made use of when the notching of the tie equal to one-third or one-half the depth of the

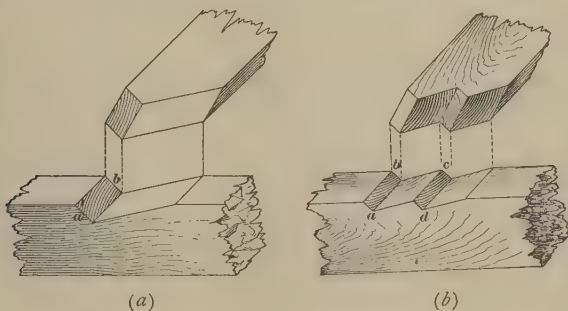


FIG. 19.

strut would weaken the beam too much. Two notches are then made, each of which should be equal to from one-sixth to one-quarter the depth of the strut, so that the sum of the two bearing surfaces *ab* and *dc*, at (*b*), is equal to the single bearing surface *ab*, at (*a*).

86. The various joints thus far considered have been for the purpose of forming a suitable union between two pieces of timber which were in different positions and which served different purposes; and with the exception of the splice joints for sills and plates, shown in Fig. 15, none of these joints could be dispensed with by getting the work out of one piece of timber.

We will now consider such joints as are for the sole purpose of lengthening timbers, in such a manner as will give the most perfect union, with the least amount of loss in strength.

87. Fishing.—A stud or post may be lengthened, or *fished*, as it is called, by the addition of an extra piece of the required length, the ends being cut square and the pieces secured together by nailing on the opposite sides of the stud two pieces of 1-inch board about 2 feet long, as shown at Fig. 20.

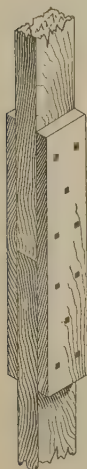


FIG. 20.

This is done only in balloon-frame construction, as in braced-frame construction, the distance between the interties and plate, or sill, should never be greater than the available length of studs. But in balloon frames, where the studs are butt jointed against both the sill and the plate without any intermediate joint, the studs frequently require to be fished, especially under the centers of gable roofs, where the height of the house is greatest. Studs can be obtained in all lengths from 13 to 24 feet, and any length in excess of 24 feet can be obtained only by splicing two pieces together.

88. In making a splice joint, attention must be given to the character of the strain to which it will be subjected, whether tension, compression, transverse strain, or torsion, and provision must be made for it to resist that strain, and at the same time to fulfil any other conditions of utility or beauty that may be required of it.

89. One of the simplest form of splice for a tie-beam or other tension member is shown in Fig. 21, where the timber *a* is simply laid against the timber *b* and bolted up with the three bolts shown at *c*. Between the bolt heads, or nuts, and the face of the timber there should be interposed, in each case, a washer *d* to prevent crushing or tearing the surface of the timber when the nut is tightened.

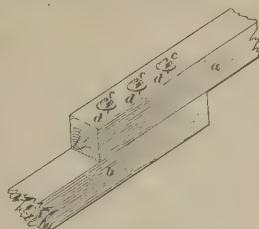


FIG. 21.

This makes a clumsy and awkward looking joint, and should seldom be used, except for temporary structures, but aside from this defect it is excellent for its purpose, and, by reason of the bolts, makes a stronger tension member than would the joint previously described for the splicing of studs, when spikes alone are used to secure the fish-plates.

90. Scarfing.—Where the joint is to be subjected to compression or tension, or both, and at the same time must preserve an appearance of neatness and good workmanship, we must resort to what is called *scarfing*, or to fishing with iron plates, or both.

Scarfing consists in the cutting and fitting of the ends of two pieces of timber in such a manner that they will enter into and fit each other so as to form a comparatively secure joint, simply from the conditions of their joining surfaces. They are usually made additionally secure by means of hardwood keys and iron bolts, or screws, but the primary consideration should be, to make the unsecured joint as strong as possible, by means of the proper proportioning of its details and parts.

91. This proportion would vary according to the strains for which the beam was intended, or to which it was likely to be subjected. In Fig. 22 is shown a form of joint which is applicable to a timber which would be submitted to compression, as the two abutting surfaces at *cd* and *ef* are equal to the entire cross-section of the timber, and are at right angles to the line of compression, but under tension

the pieces would immediately pull apart unless secured, as shown, by means of bolts and straps, in which case the entire tensile strain would have to be borne by the straps and the sections of beam immediately under them and between the bolt holes and the end of the beam; and the bolts themselves would be subjected to a shearing strain.

Again, in Fig. 23, we have a joint which, under compressive strains, would be all that is ordinarily required, but if submitted to tension, the entire strain would be borne by the keys *r*, *s* and the iron bolts *m*. It is evident in Fig. 23 that the failing of this joint under a tensile strain would be caused by one or more of the following five conditions: The keys *r*, *s* might shear through and permit the two pieces to slide apart; or, if secured by bolts, the bolts might shear and have the same result. The wood of the beam might split or shear off on some line from *o* to *d e*, allowing the pieces to pull apart without disturbing the keys; or, the beam might part under the tension at the thinnest point, as at *b*; or, the bolts might remain intact, but the material between them and the end of the beam might be sheared off and permit the beams to separate.

92. It is evident, therefore, that in order to secure the greatest tensile strength combined with the most economical distribution of material, the following conditions must exist in any scarf joint, no matter what its form may be:

The sections of the timber subjected to a shearing strain must be so proportioned that their shearing value will be equal to the portions of the timber subjected to a tensile strain; and if the joint is additionally secured by means of iron bolts or plates, or both, the combined tensile strength of all the members submitted to tension must be equal to the combined strength of the members submitted to shear.

For example, if we use a joint of the form shown in Fig. 23 for a beam subjected to tensile strain, and omit the four bolts *m*, we must proportion the parts so that the shearing strength of the keys *r*, *s*, and the shearing strength of the material between *o* and *d e* or between *p* and *i j* will equal the tensile strength of the section at *b*. For, no matter how much

stronger any one of these details may be than is required of it, the beam will not acquire additional strength thereby, as it will only be as strong as its weakest part.

The importance of analyzing the conditions under which a beam will be strained is, therefore, very evident, and it is the comprehension of these conditions, and the knowledge of how to provide for them, that enables us to select a proper form of scarf joint in each particular case.

93. Fig. 22 shows the simplest form of a *scarf joint*. The timber *a* is cut half through its depth, on the line *cd*, which is perpendicular to the adjoining face of the timber, as is also the line *cg*. The timber *b* is similarly cut half its depth on the line *ef*. The material between these cuts and the end of the timber is then removed to the line *de*, and the two pieces *a* and *b* are then joined in the same manner as the splice joints in Figs. 14 and 15, and are securely bolted. Thus

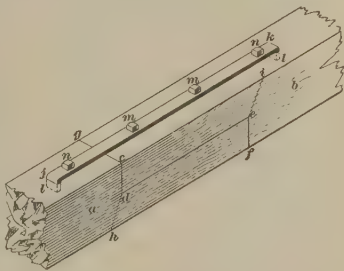


FIG. 22.

far the joint presents the same mechanical features under tension as would the joint shown in Fig. 21; but when subjected to compression the timbers *a* and *b* have a flat bearing on the surfaces in contact at *gcd* and at *ef*, which, combined, are equal to the entire bearing surface of the end of the timber, each surface being the full breadth by half the depth. The weakness of the joint under compression arises, therefore, from its tendency to bend and fail, either through the parting of the bolts, or from the breaking of one of the laps near the lines *ei* or *dh*. This weakness can be compensated, however, by bolting to the top and bottom of the timber an iron plate or bar *jk*, whose length is equal to twice the length of the joint *de*, with a breadth equal to one-third of the breadth of the beam, and a thickness proportioned according to the strain it is likely to be subjected to. These iron bars

are usually turned over on the ends, as shown at *l*, and let into the top of the timber. The two bolts *n* merely hold the ends in place, while the bolts *m* pass through both the bars and the laps of the joint.

The iron bar prevents the timber from bending in the direction of its depth, and the bolts *m* and the bearing surfaces *g c d* and *e f* prevent it from bending in the direction of its breadth under compression, while the bolts *m*, combined with the bars *j k*, and the turned-in ends, or lugs *l*, prevent the joint from parting under tension. This joint is not adaptable to a tensile strain, however, as its strength would depend entirely on the shearing value of the bolts *m* and *l*, and the tension of the bar *j k*. Nor is it fit for a transverse strain, which might bend the iron bar and tear out the bolts.

94. If the timber shrinks after the scarfing is complete and the beam is in place, this joint will work loose and cause trouble unless it is carefully watched and the bolts are tightened up from time to time, until the wood is thoroughly dried out and the shrinkage ceases.

The proper length of the joint on the line *d c* varies with the material and the circumstances, as will be explained further on.

95. In Fig. 23 is shown another form of this joint, where the combined bearing surfaces of the two pieces *a* and *b* is still equal to the sectional area of the timber, and

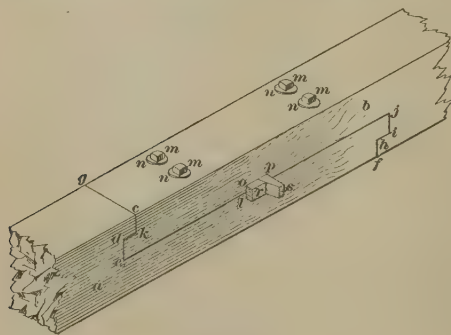


FIG. 23.

the tendency to bend in the direction of the depth is lessened by the form of the scarfed ends of the joint without the use of an iron plate or bar; the joint, however, is not adapted to a transverse strain, as the parts are cut away too

much. The timbers a and b are first sawed half through their depth and prepared in the same manner as for the joint in Fig. 22, but from the top of the lap, and at a distance from the end of the timber equal to half the thickness of the lap, the timber is again sawed through, until the line ck , on timber b , is equal to one-quarter the depth of the entire timber, or one-half the depth of the lap. The material between ck and the end of the lap is then removed, and on the shoulders of timbers a and b , half way between the surface and the projecting lap, the timber is sawed through in the direction of its length a distance kd , on timber a , equal to one-half the thickness of the lap. The material between ke and the face of the shoulder is then removed with a chisel, care being taken to keep the surfaces parallel and true throughout the thickness of the timber. The pieces a and b are then fitted nicely together in the position shown in Fig. 23, and at the middle of the line of the joint cj is marked the position of the rectangular hole lop , the depth lo being equal to about one-sixth the depth of the timber, and the length of the hole op being twice the depth lo . The timbers are then separated and half the hole lop is cut in each piece separately, and the distance from o to e , on timber b , is made $\frac{1}{16}$ to $\frac{1}{8}$ of an inch greater than the distance le on timber a . When the pieces are finally put together, a pair of wedge-shaped keys rs are driven into the hole, thereby forcing all the bearing surfaces into close contact. Holes are then bored through the depth of the timbers and four bolts m are inserted and screwed up tight against the circular washers n .

96. The advantage of this joint over that shown in Fig. 22, is that it is not so seriously affected by shrinkage, and at the same time preserves the most favorable feature of a beam under compression—that of a full bearing surface, equal to the cross-section of the beam. Should the two pieces composing the joint shown in Fig. 23 shrink to any considerable extent, the only result would be the loosening of the bolts m , unless the keys r and s were made of some

harder wood than the beams themselves, and, therefore, did not shrink as much in proportion. This would cause the joint to open slightly at the middle part of the line ej , but it could be prevented by making the keys about $\frac{1}{16}$ inch less in thickness than the hole at lo . Shrinkage would then not affect the appearance of the joint at all, and the bolts could be tightened from time to time, as in the previous case; the joints being thus maintained close and secure at all times.

This joint is better adapted to resist compression than tension, as under tension the entire strain would come upon the bolts m and the keys r, s . Great care should therefore be exercised when this joint is to be submitted to tensile strains, to see that the bolts fit the holes tightly, and that the keys are well driven, otherwise, under alternate compression and tension, the joint is liable to work loose. The projecting ends of the pieces at de and ji serve only to keep the top of the joint flush.

97. The joint shown in Fig. 24 is similar in construction to that in Fig. 23, except that the line de is carried through the timber in a slanting direction instead of parallel to the top and bottom, and is not continuous in each timber; that is, the line of juncture on timber a extends from d to l and then makes a break lo at right angles to dl and then proceeds from o to e at the same angle it started. The

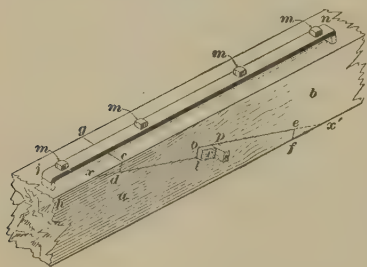


FIG. 24.

extent of this slant from the surface of the timber depends upon the length of the joint, as the cuts dc and ef should never be less than one-sixth the depth of the timber when at right angles to de , and when the angle cdl is less than 90 degrees the distance cd should be increased.

98. This style of joint is not as strong as that in Fig. 23 when subjected to compression, but is somewhat stronger

under tensile strain, as part of the stress is taken up by the iron bar jn , which is applied in the same manner as in Fig. 22. It is well adapted to a transverse strain, however, and when so intended, slight modification should be made, according to circumstances. When a beam is submitted to a transverse strain, its top is in compression and its under side is in tension; therefore, a combination of two forms of joint should be made to suit the two conditions. When the joint shown in Fig. 24 is used as a beam with a transverse strain, it is better to let the line cd run at right angles to the top of the beam and extend half way through, as the line cd in Fig. 22. This adapts the upper half to a compressive strain, while the under side may be scarfed, as ocf in Fig. 24, and have an iron bar or plate on the bottom.

The rectangular hole, or keyway, lop has its long side on the cuts oe and dl , and the keys r and s have each a full bearing surface on one timber instead of a half bearing on each timber, as the keys in Fig. 23. Under compression, however, there is a tendency for the joint to slide on the line de and split off the small bearing triangles cdx and fcx' . The iron bar could hardly be expected to prevent this, as it would probably bend away from the timber between the bolts, and a square butt end, as above described, should, in such a case, be used. In this joint the keys r, s must be driven with caution, as the least overdriving would tend to split the timber on the line dx or ex' .

99. Shrinkage in the material in this joint would first cause it to open slightly on the line de ; then, if the timber were under compression, this would be compensated by the sliding of the two pieces into close contact again, and the consequent loosening of the keys r, s ; but if the timber were subjected to a tensile strain, the joint would remain open on the line de until the keys r and s were driven tighter to close the joint, and the bolts m were tightened to hold it in place after the shrinkage had been taken up.

100. Fig. 25 is a modification of Fig. 24, in having the line de continuous and passing it through the center of the

keyway rs , and also in having the meeting line of the two timbers cut at an obtuse angle chg . This renders the beam much more reliable under a cross-strain tending to bend it in the direction of its width, and the pointed toe also tends to keep the timbers flush. Like Fig.

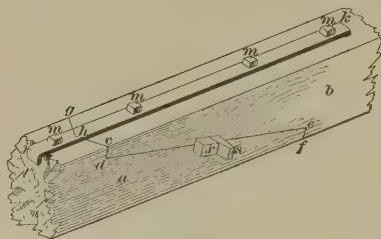


FIG. 25.

24, this joint is better

suited to a tensile than compressive strain, but its behavior after shrinkage is more like that shown in Fig. 23. If used in a position where it will be subjected to a transverse strain, it should have the upper half prepared as described in Art. 98.

101. A method of lengthening timber and preserving a considerable degree of strength, both for longitudinal and for transverse strains, is shown in Fig. 26. Three thicknesses a , b , and c of the same size of timber are bolted together with four bolts m , the joints fg and hde being squarely sawed and tightly

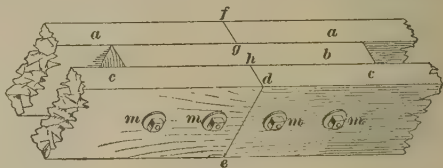


FIG. 26.

butted, in order to secure a good bearing. The bolts must fit the holes exactly, and the nuts on their ends must be screwed as tight as possible, as upon the bolts depends the entire strength of the joint.

102. In proportioning these scarf and lap joints, in oak, ash, elm, or hard pine, the whole length of the joint should be about six times the depth of the timber, when no bolts or plates are used, and the permanence of the union of the pieces depends upon the keys alone; but when bolts are used, the length of the joint should be about three times the depth of the beam, and when both means are adopted, or iron plates are interposed between the bolt heads and the

timber, the joint can be as short as twice the depth of the beam. With pine and similar soft woods the length of the scarf should be twelve times the depth of the timber when there are no bolts to sustain the piece, and when reinforced by bolts, six times the depth; or with bolts and plates, a length of four times the depth of the timber is considered sufficient.

103. In Fig. 27 is shown a form of joint more suitable for a short post than either of the foregoing scarfed joints, but it is unfitted for tensile strain. The ends of the timbers *a* and *b* are carefully squared on the line *cde*, and in the center of the end of each piece is bored a hole to take the stud bolt, shown dotted at *fg*; at a distance from the end of each, and not less than two-thirds the thickness of the post, a square hole *h* is cut where the nut for the bolt is inserted, and through which it is screwed tight upon each end of the stud bolt. This brings both ends of the post into close contact, so that there will not be any perceptible compression at this point when the working load is imposed.

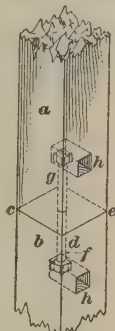


FIG. 27.

104. In Fig. 28 is a cheaper form of joint for a similar purpose, though this may also be used in positions where it will occasionally be subjected to slight tensile strain. It is an improved form of that shown in Fig. 20, but with *indents* cut at *def*, in order that any tensile strain will come upon the wooden fish-plates, or battens *c*, and the lugs of the timbers, and not entirely upon the nails, or spikes, as is the case in Fig. 20. The thickness of the plates *c* should each be equal to not less than one-quarter the depth of the timbers *a* and *b*, and the indents *def* should be not more than one-third the thickness of the fish-plates. The entire length of the joint from *d* to *d'* may be three times the timber depth, and the length of the indent from *f* to *d* about one-quarter the



FIG. 28.

length of the joint. The fish-plates may then be bolted through the timber from side to side with four bolts, or may be spiked to each side with from eight to twelve spikes, as shown.

105. In Fig. 29 the fish-plates are replaced by iron straps *c* not less in breadth than one-sixth the thickness of the timber, and sunk into the face of the wood a depth equal to their thickness, as shown at *e*. Holes are bored or punched in these straps to receive the lagscrews, or spikes, which serve to bind the timbers and straps together, and the iron, or hardwood dowel *d*, in the center of the posts, serves to keep the two pieces in alinement. This joint is suited only for compressive strains, and with Figs. 27 and 28, should be used only in a perpendicular position, unless the joint itself is independently supported.

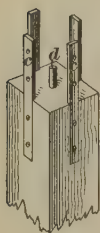


FIG. 29.

This completes the description of some of the joints most commonly used in the framing of buildings, and we will now proceed to the details of general framing.

FRAMING.

SILLS, POSTS, AND STUDS.

106. The carpenter's work in a frame building usually commences when the foundation is completed. First, a timber, called the *sill* (see *a*, Fig. 12), is laid upon the top of the foundation wall to receive the superstructure of wood. This sill varies from 6 in. $\times$ 8 in. to 8 in. $\times$ 10 in. in regular framed buildings; and from 4 in. $\times$ 6 in. to 4 in. $\times$ 8 in. in balloon-framed buildings, and is laid about 1 inch from the outer face of the foundation wall. The corners of the sill are *halved*, as shown in Fig. 14, and when necessary to splice it in order to cover a longer run of wall than can be

accomplished by one piece of timber, the *beveled-splicing* joint, shown in Fig. 15, is usually adopted.

The corner posts are then erected at the angles of the building, as shown at *b*, Fig. 12, and are usually composed of from 6"×8" to 8"×10" timbers in regular frames and of from 4"×6" to 6"×10" timbers in balloon frames. The lower end of the corner post is generally mortised into the sill at the halved corner and its upper end is mortised to the plate *h*, Fig. 12, although in balloon-framed work the plate is sometimes merely spiked to the end of the corner posts, the internal angle being formed by spiking a stud to the face of the corner post.

107. The studs *k*, Fig. 12, are sometimes mortised into the sill *a*, into the girt, or intertie *d*, and into the plate *h*, although in modern work they are more frequently simply butt jointed in position, except in the case of double studs at the sides of openings; while in balloon-framed work they should always extend from the sill to the plate in one piece, if possible, or be spliced in the manner shown in Fig. 20, where the height is too great. To carry the floorbeams in the second or third story, a *ledger board*, or *ribbon*, shown at *k*, in Fig. 72, is notched into the studs, each beam being spiked to the adjacent stud. In regular frames the upper floorbeams rest upon the intertie, as shown at *i*, in Fig. 12.

FLOORS.

108. Floorbeams are *sized* or notched on the sill, as shown in Fig. 30, in order to bring their tops to an even line, any variation in the depth of the beams *b* being removed with the notch at *e d*, so that all the beams are exactly the same depth from *a* to *c*, thus securing an alinement of their upper edges. Nearly all timbers will curl or warp more or less in drying out, or seasoning, and when floorbeams are laid they should be placed with this convex, or *crowning*, side upwards, in order that any deflection of the beam due to the

superimposed weight will bring the floor to a level line rather than produce a sag or dip in the middle of its span.

In the second story of a building the beams are notched over the interties, or girts, in the same manner as over the sill, and in balloon frames, where the girt may be but an inch in thickness, the floorbeams are cut on the under side, forming a channel, or groove, across the beam which rests on the girt, and not only brings the tops of the beams to a level, but also forms a tie across the building. In brick or stone walls, the beams are maintained at the same level by

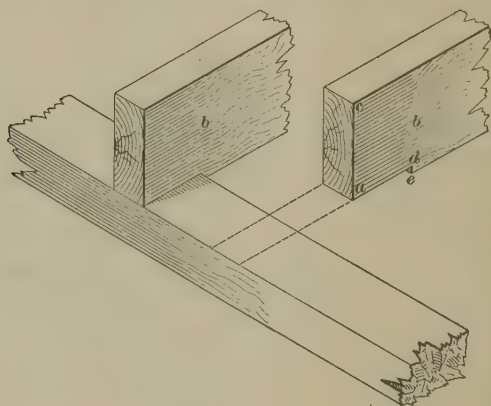


FIG. 30.

placing small pieces of slate under the shallower beams, and thus raising them to the proper level. Thin slips of wood are sometimes used instead of slate, but as they are seldom made of a uniform thickness, and squeeze readily under pressure, they are not to be recommended. The method of tying such beams into a brick wall is shown at *k*, Fig. 32, where a strip of iron not less than $\frac{3}{8}$ in. $\times$ $1\frac{1}{2}$ in. in section, called an *anchor*, is nailed to the side of the beam, and its end, which is bent around a $\frac{3}{8}$ -inch iron rod, is allowed to project from 4 inches to 8 inches beyond the end of the beam, and the brick or stone work is then carried up around it, enclosing the anchor and securing the beam.

109. Bridging is the term given to a system of bracing applied between floorbeams in order to prevent them from bending sidewise, or curling out of position after they are in place. They also tend to strengthen the floor system when it is not uniformly loaded, by distributing the weight among the adjacent joists. Fig. 31 shows a method by which this is accomplished, called *herring-bone* bridging, in

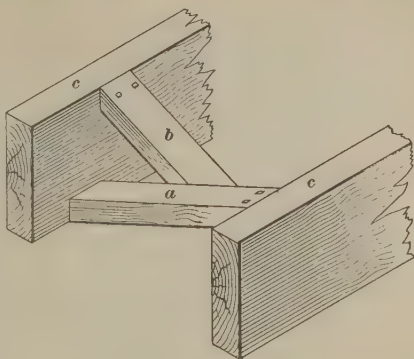


FIG. 31.

distinction from other forms of bridging to be described subsequently. The herring-bone bridging shown in Fig. 31, is generally formed of 2" $\times$ 4" pieces *a* and *b* cut between, and well nailed to, the joists *c*, as shown, and spaced in rows about 8 feet apart.

110. Trimmer Beams.—Where a chimney occurs in the side wall or in the center of a building, it is necessary to *frame* the floorbeams in such a manner that no wooden beam shall come within 4 inches of the brickwork enclosing a chimney flue. This is accomplished as shown in Fig. 32, the method of framing and the joints required having been already described. When there is to be a fireplace opening and hearth in front of the chimney, the header *a*, Fig. 32, should be placed from 1 ft. 9 in. to 2 ft. 6 in. away from the chimney breast, in order to provide room for a trimmer arch, as shown at *a*, in Fig. 80.

This method of framing with *headers*, *trimmers*, and *tail-beams* is also used around the openings for stairs, skylights, dormers, and dumb-waiter shafts. In all cases the header *a* and the trimmers *d*, Fig. 32, are made at least twice, or three times the thickness of the regular floorbeams *b* and *k*,

as upon these trimmers is imposed the combined load of all the tail-beams *b*.

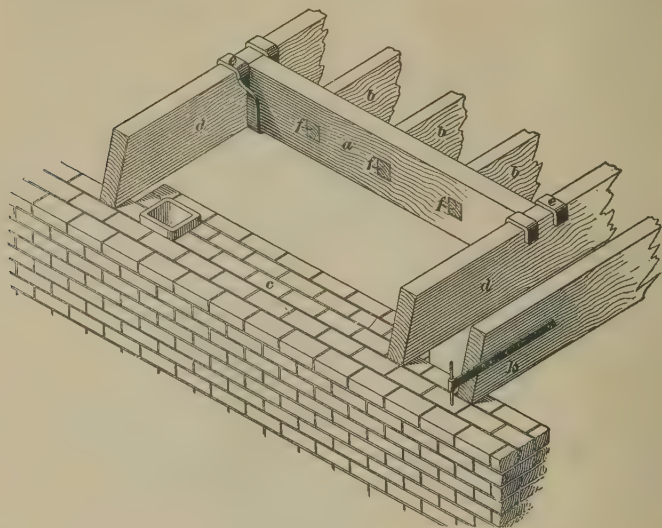


FIG. 32.

111. Flooring is applied directly to the top of the joists, after they have been brought to a true alinement, as above described, and is *plain* or *matched*, *single* or *double*, as the case and character of the building requires.

A plain floor consists simply of second quality boards nailed directly to the floorbeams, each plank being from 6 in. to 10 in. in breadth, and forming a butt joint with its neighbor. Such a primitive floor is seldom used except in temporary structures.

A matched floor is laid with selected material which has been *matched*, or *tongued and grooved*, as shown in Fig. 33. This matching, though formerly worked entirely by hand, can now be done by machinery at the mill where the material is cut up from the seasoned timber, and matched flooring is a commercial article purchasable at any lumber yard.

112. Matched floor boards, when laid, are about $\frac{3}{8}$ of an inch narrower than the width at which they are purchased,

which shortage represents the amount cut away in the milling. At *a*, *b*, and *c*, Fig. 33, are shown three pieces of matched 4-inch flooring, which measures, when laid, but $3\frac{5}{8}$ inches as shown, but the tongue *d* projects $\frac{1}{4}$ inch, making the total width of the board $3\frac{7}{8}$ inches; the remaining $\frac{1}{8}$ inch being lost partly in waste in the process of matching, and partly

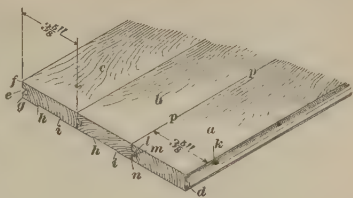


FIG. 33.

by shrinkage after the matching has been done. At one edge of the board a projecting rib *d*, called the *tongue*, is cut, and on the opposite side a groove *e* is sunk a trifle deeper than the projection of the tongue. The upper edge *f* of the groove projects about $\frac{1}{32}$ inch more than the lower edge, so that when the flooring is laid and the groove is driven tight on to the tongue, as at *l*, the $\frac{1}{32}$ -inch clearance between the front of the tongue and the bottom of the groove at *m*, and between the shoulder of the tongue and the lower edge of the groove at *n*, leaves the upper edge of the groove to be driven tight against the upper shoulder of the tongue, thereby forming a tight joint on the surface, as shown at *p*.

The same result is obtained by keeping the under shoulder of the tongue slack, in which case the grooved edge would be square. The tongue is always placed slightly below the center of the thickness, so as to give more wearing surface to the floor and render the edge of the groove less likely to curl up.

When this matched flooring is of hardwood, such as oak, maple, or yellow pine, a shallow groove about $\frac{1}{32}$ inch deep is cut along the under side, as shown on pieces *b* and *c* at *h i*. This enables the boards to be laid tight to the beams or under flooring, and causes them to be less affected by any slight unevenness of the substructure.

113. Matched flooring should always be *blind nailed*; that is, the nails should be driven in the upper angle of the tongue, as shown at *k*, in a diagonal direction, and, in the

hardwoods, the nails should be punched in, so that their heads are well below the surface, and as the groove of the next piece covers the tongue, it hides them from sight. The boards are nailed only on the tongue edge, as the groove edge is held fast by the tongue. Next the wall, on both sides of the room, it is necessary to nail the first and last board through the upper face. As the baseboard will cover these nails the entire floor will present an even surface, without a nail head in sight.

This description of flooring would more often apply in the case of a double floor, though a first-class job of a single matched floor would demand equal care.

114. A *double floor* consists of a rough, plain, or matched floor of boards (preferably matched), laid when all the beams are in place and bridged, and of a second, or finished floor, of the character just described in detail, laid when all the rough work in the building is complete, and when the joiner work is in progress. In first-class work, the finished floor should not be laid until the base, window and door trim, etc., have been fixed in place.

Over the rough floor of a building, all the coarse work is carried on, such as lathing, plastering, and the first coats of painting.

115. When two thicknesses of flooring are laid, the first,

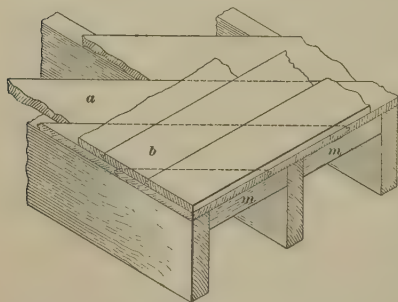


FIG. 34.

or under floor, is usually laid diagonally across the beams, as shown at *a*, Fig. 34, and the second, or finished floor, is laid on top of this, but at right angles to the beams, as shown at *b*. When the rough floor is laid at right angles to the beams, and the finished floor runs in the

same direction on top of it, the shrinking of the wide boards

beneath may pull two or three of the boards of the finished floor up tightly together, thereby leaving open joints in the upper floor at regular intervals, corresponding very nearly with the widths of the rough boards below. The diagonal laying of the lower flooring obviates this difficulty, and to insure an even bearing all around, it is sometimes necessary to nail between the beams, at their ends, some supporting pieces *m, m*, Fig. 34, to which the diagonal boards may be spiked. The rough floor should be well nailed to the joists, and care should be taken that the finished floor is nailed only over the joists; when driven into the boards the nails possess little value, and are likely to work loose. For floors $\frac{7}{8}$ inch thick, $2\frac{1}{2}$ -inch cut nails should be used, and for $1\frac{1}{8}$ -inch floors, 3-inch nails.

The thickness of the boards in the lower and upper layers of a double floor are usually 1 inch and $\frac{7}{8}$ inch, respectively, but single floors in dwellings should have the boards at least $1\frac{1}{8}$ inches thick. In mills, factories, warehouses, etc., the flooring varies from $1\frac{1}{8}$ to 4 inches in thickness, as will be explained further on.

PARTITIONS.

116. Partitions are constructed of pieces of timber from 2 in. $\times$ 4 in. to 3 in. $\times$ 6 in. in section, called **studs**, which are set vertically, with the depth of the stud in the direction of the thickness of the partition, and are spaced 12 inches or 16 inches on centers, in order to accommodate the 4-foot lengths of lath which they are to carry. Any difference that may be required in spacing should be made at one end of the room, or, where the irregularity of spacing is caused by the insertion of a door or window, the difference should be made entirely on one side of the opening. Every spacing of studs which is a variation of the above will cause the laths to project past, or fall short of, the desired nailing point for their ends, necessitating in either case the cutting of the lath at the center of the nearest stud, thereby causing an expenditure of time and a waste of material.

- 117.** Where partitions are required in a direction across the floorbeams, as shown in Fig. 35, a sill *a* is first laid on the beams and perpendicularly over it, and on the under side of the ceiling beams is nailed a *cap*, shown at *b*, Fig. 36; between this sill and cap the studs are set and securely toe-nailed through each end.

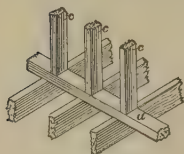


FIG. 35.

- 118.** In Fig. 37 is shown a method of securing a firm internal angle at the corner of a building. *a* is the corner post of a building resting upon the sill *s*, and *b'*, *b*, *b* are the studs of the outside wall. The corner post in this case is made with a 4"×6" piece *a*, and a 2"×4" stud *b'* spiked to it flush with the outside. This arrangement leaves the two surfaces *c* and *e*, to which the ends of the lath of each wall may be securely nailed.

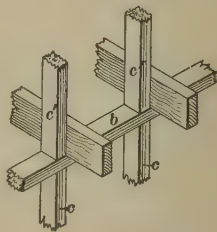


FIG. 36.

- 119.** In Fig. 38 is shown a method of forming the interior angles where partitions are placed at right angles

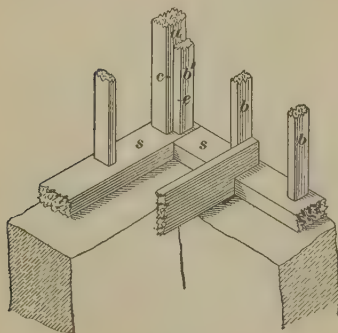


FIG. 37.

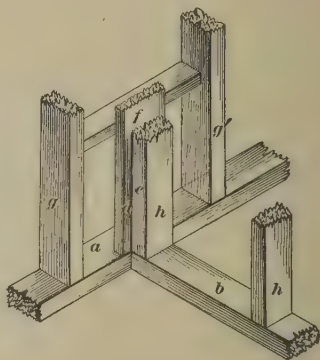


FIG. 38.

to each other; *g*, *g'* are two studs, which may also be in the

outside wall of a building, and h, h are the studs of an interior partition. At f on the partition, or wall, is a piece of plank 1 inch thick and 2 inches wider than the stud h to which it is nailed, and extending from the sill a to the top of the partition, thus affording a surface on each partition where the lath ends may be nailed, as at d' and c . A strip may with advantage be nailed on top of the sill, to which the plank f can be nailed.

120. When the partition of an upper story comes vertically over one in the story below, the studs of the upper one should be set upon the cap of the one below, as shown at c' , Fig. 36, and not upon the beams, as in Fig. 35.

This reduces the effects caused by the shrinkage of the timbers, which is bound to occur as the building dries out, and the fewer transverse thicknesses we have as supporting members to partitions, etc., the less will be the shrinkage and ultimate settlement of the whole house.

When a partition runs parallel with the beams it should stand on a beam framed in especially to receive it, or it should rest on the cap of the partition below, if such a partition exists.

121. All important partitions should be well supported at their foundations, either by a brick wall or by a girder carried upon brick piers or wooden posts, with masonry footings. This girder should be very little deeper than the sill of the house, or, when extra depth is demanded by the degree of strength required, the ends of the beams may be notched over the edge of the girder in somewhat the same manner as the floorbeams are notched over the sill in Fig. 30. In this way the amount of shrinkable material between the top of the post and the bottom of the partition studs may be reduced to very nearly the same as it would be in the sill under the outside walls; or, if the girder cannot be notched sufficiently to effect this, the house sill may be made somewhat thicker, or the floorbeams must be set with their interior ends slightly raised, so that subsequent shrinkage of the girder will render

them level. It is shrinkage of material that causes new houses to settle, and if the settlement is uniform, no harm results from it, but irregular settlement causes uneven floors, cracked plaster, and doors and windows that refuse to open readily or close tightly.

Good, sound, well dried material, therefore, should always be used, when such is obtainable, and all unsound, curved, knotty, or shaky timber should be rejected as unfit for any purpose except firewood.

122. Lathing is applied to the partitions as soon after the studs are in place as is convenient. Where pipes or wires are to be carried within the walls, it is sometimes necessary to delay at least a portion of the lathing until they are in place; or, when the exact location of these interior lines is determined upon, the lath may be left off one side of the partition until the wiring or pipe lines have been inserted.

Laths consist of strips of soft wood, generally $1\frac{1}{2}$ inches wide, $\frac{1}{4}$ inch thick, and 48 inches long; they are laid horizontally on the partitions, nailed to each stud, and maintained, as nearly as possible, at a uniform distance apart—usually from $\frac{1}{4}$ to $\frac{3}{8}$ inch, as shown at *g*, in Fig. 43.

To guard against unsightly cracks in the plaster at the angles of the rooms, suitable nailing strips, as *d* and *e*, Fig. 38, or double studs, as *a* and *b'*, Fig. 37, must always be provided; and *under no circumstances* must the lath be permitted to extend across from one stud to another behind the end of a partition, as from *g* to *g'*, Fig. 38.

123. Plaster Grounds.—Where any woodwork is to be applied against a plastered wall, such as a baseboard, chair rail, wainscot, picture molding, etc., it is always necessary to provide a proper bearing to nail it against, in order to avoid cracked plaster and insecure fastening, which would result from nailing through to the lath and plaster into the stud. Therefore, a **ground**, or nailing strip *a*, Fig. 73, is nailed against the studding at such a height as the top of the base,

or other trim, will reach, and of a thickness equal to that of the lath and plaster. To this *ground* the trim is fastened when the plastering is finished and dry. When the trim to be applied is in the form of a wainscot or other wide surface, it is sometimes necessary to have several grounds at different heights, to which the separate pieces may be attached. It is always desirable in first-class work to have the walls lathed below the grounds, even down to the floor line, and also plastered to that point, as the back of the trim is thereby protected from exterior dampness and drafts, and vermin have less opportunity to make passages behind the walls.

124. Though the primary purpose of grounds is to form suitable nailing places for interior trim, they, at the same time, exercise another and most important function—that of forming a stop for the plaster. If no grounds are provided, and the plaster is simply carried to some arbitrary point which will be hidden behind the trim, we have an insecure job, the edges of which are liable to break off and crack as the trim is put in place, thereby necessitating patching and repairing after the job is complete; but if a ground is placed at every side where the plaster will stop, the entire wall surface is enclosed in a frame, and is secure from damage.

125. When lathing is applied to the ceiling of a room, it is sometimes nailed directly to the under side of the ceiling beams, though in first-class jobs it is always best to provide some means of bringing the bottoms of the ceiling beams to a level alinement before the lath is nailed on.

126. Cross-Furring.—In Art. 108 is explained the method employed to bring the top of all the floorbeams into alinement, and, as will be readily seen, any irregularity in the depths of the beams will, by this method, be thrown to the under side. Therefore, when the under side of these beams is to carry a plastered ceiling, they must first be leveled by a system of *cross-furring*. This is accomplished by nailing thereon furring strips 1 inch thick by 2 inches

wide, and spacing them 12 inches on centers. These furring strips are either notched over the beams or dropped below them by the insertion of slips to bring them in line.

On these furring strips the laths are then nailed, and if, on any side of the room, there is no beam in the angle between the side wall and the ceiling to which a furring strip can be nailed to secure a firm corner, pieces must be nailed on the plate of the partition to receive the ends of the strips, in the same manner as nailing places were established at *ec* and *ed*, in Figs. 37 and 38, to receive the ends of the lath. When a ceiling is cross-furred, it is more rigid; the plaster is less liable to crack by the vibration of the floor-beams, and, being generally of less width than the thickness of the joists, a better rivet is secured for the plaster.

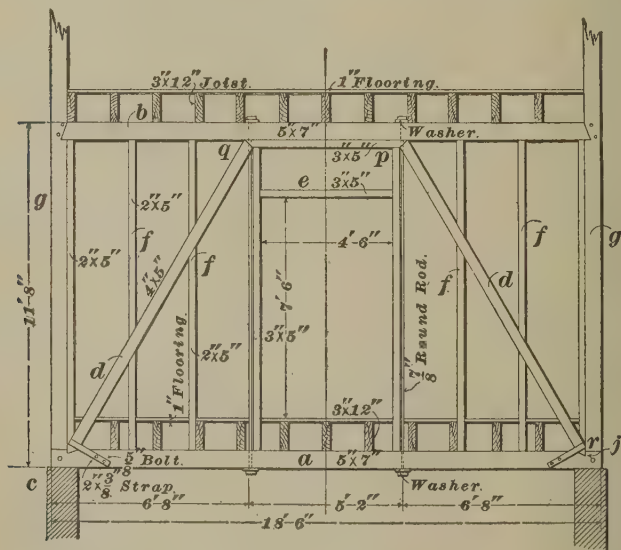


FIG. 39.

127. Trussed partitions are sometimes necessary where there is no supporting partition in the story below, or where a partition has a number of doors or other openings through

it so weakening it that it cannot safely carry the required weight to be imposed upon it. Fig. 39 shows a trussed partition with a door 4 ft. 6 in. $\times$ 7 ft. 6 in. in the center of it. The sill a and the plate b are made 5 in. $\times$ 7 in. The studs c at each side of the door are 3 in. $\times$ 5 in., and the upright wall members g are 6 in. $\times$ 5 in. The height of the door is limited by the 3" $\times$ 5" timber e ; from the ends of the timber p the braces d extend to the ends of the sill a , where they are *let in* at j , to secure them from slipping. A truss cqr is thereby framed, around the members of which the 2" $\times$ 5" studs f are cut. The entire weight of this partition, together with any superimposed load, will come upon the points c and r , where ample support must be provided to carry the weight down to a proper foundation.

128. In Fig. 40 we have a partition with three openings, the essential difference between it and that shown in Fig. 39

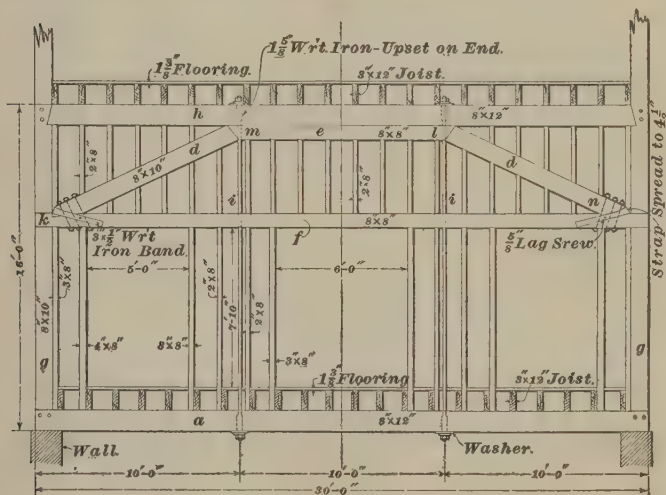


FIG. 40.

being that the truss is entirely above the openings, while in the former example the opening was through the center of the truss. In Fig. 40 we have the sill a , into which are

mortised the wall members *g*. The tie-beam *f* marks the top of the openings, and into it the rafters, or struts, *d* are notched at each end, with the compression member *c* between their tops. This entire truss *km ln* is carried by the wall posts *g*, and the weight of the door posts and the studs between them is carried to the top of the truss through the tie-rods *i*, which pass, also, through the plate *h*; the weight of the entire partition is therefore carried by the corner, or wall posts *g*, which, in turn, must be well supported from below.

129. Door and window openings more than 3 feet wide, should have their heads trussed, as in Fig. 41, the tie-beam *c* resting upon the studs *d*, and the struts *e* footed into the tie-beam. This prevents the top of the door from sagging in the center, as the superimposed load is all carried to the side studs *d*.

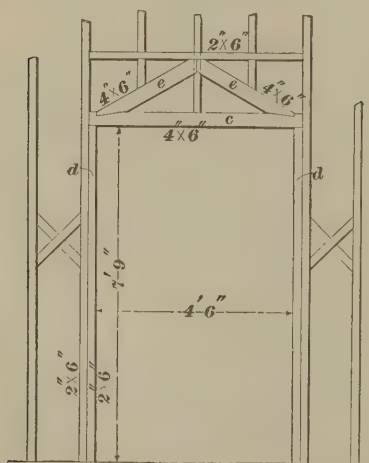


FIG. 41.

Double studs, or larger sized studs, should, therefore, always form the sides of door and window openings, as shown at *d*, Figs. 41, 42, and 43, for the purpose of gaining strength and also to afford a nailing place for the trim. When a single piece of timber of the proper size for this is not at hand, it is customary to spike together two pieces of the ordinary studding and use them as a double stud, as shown at *d*, Fig. 42.

130. The sizes of doors and windows as marked on plans or working drawings are the dimensions of the finished parts, and in framing the openings for them in the studding, an allowance must be made for windows of about 5 inches

in height and 7 inches in width, where there are weights; but if the window is to be hung without weights, an allowance of 3 inches at the sides will be sufficient.

In door openings, false jambs are generally inserted, as shown at *c*, Fig. 43. These are nailed to the studs, and the plaster finished to them, in order to make the sides of the opening perfectly vertical and the top level; therefore, an

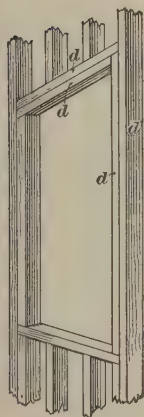


FIG. 42.

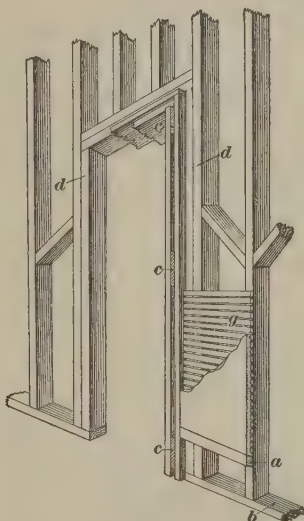


FIG. 43.

allowance of about 5 inches in width, and 3 inches in height is required in framing the stud openings for doors, and an ordinary door, 2 ft. 10 in. $\times$ 7 ft., would require a framed opening 3 ft. 3 in. $\times$ 7 ft. 3 in. When setting the finished jamb, solid blocks should be placed where the hinges of the door will come, as shown in Fig. 43.

THE FRAMING OF ROOFS.

131. A *roof* may contribute much to the elegance and completeness of any building, as, by its fitness and appropriateness of outline, and its harmony with the structure, it

crowns the whole. The angle to which any roof may be built, is variously designated as the pitch, slope, or inclination. There is, in practice, a rule for calculating a roof pitch by the proportion of its span to its height; however, the most simple and practical way of treating this pitch is by calculating the rise, or vertical height, in proportion to the foot of horizontal run.

132. According to the manner of pitching a roof in one or more directions, there is given to it a particular name, which may express the character of the whole roof, or merely name one of its characteristics. A *flat* roof is one where there is but a slight pitch, or slant, to its timbers, just sufficient to cause the water to run to its lower edge, which is called the *eaves*.

The amount of pitch usually given to a flat roof varies from $\frac{1}{4}$ inch to 3 inches to a foot, according to circumstances; when the inclination of the roof materially exceeds 3 inches to the foot, the roof comes under the class of *single-pitch*, or shed, roof, sometimes called a *lean-to*, as shown in Fig. 44.

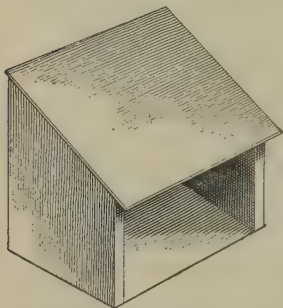


FIG. 44.

This kind of an enclosure is usually built against the side of another structure, already erected—hence its name *lean-to*—and its roof often has to receive and carry the drip from the main roof above,

as well as its own collection of moisture. The single-pitch roof, however, is also frequently used over verandas, and attic dormer-windows, and in other minor positions on the main building.

133. When the pitch falls in both directions from the center of the building, we have what is known as a double-pitch, or **gable**, roof, as shown in Fig. 45, the plan of which

is the rectangle $fghi$. This form of roof derives its name from the shape of its ends, the triangle abc being called a *gable*, one of which exists at each end of the building. The upper edge of the roof be is called the *ridge*, and the lower edges, on each side, as at cd , are called the *eaves*. In the plan fi and gh are the eaves, while jk shows the position of the ridge be .

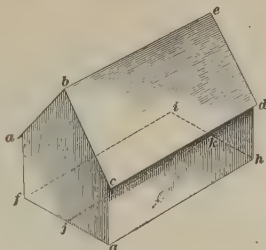


FIG. 45.

134. In Fig. 46 (a) is shown in perspective a square structure, with a gable on each of the four sides. The ridges of these gables intersect at o , while the eaves intersect in pairs at a, c and e ; the line of intersection oc between the pitches dc and bc , is called a *valley*. At (b) is shown a plan of this roof, in which the lines $d'h'$ and $f'b'$ mark the positions of the ridges, the lines $o'a', o'c', o'e'$, and $o'g'$ show the intersections of the slanting surfaces, called valleys, while the dotted outline $g'i'a'$ is the form of the elevation of the gable over $g'h'a'$.

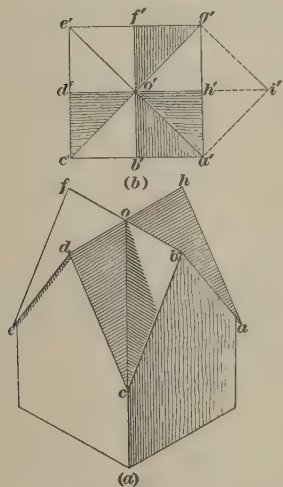


FIG. 46.

135. In Fig. 47 (a) is illustrated a rectangular building with a roof pitched back from all four sides, forming a pyramid. The edges oa, ob , and od , in which these pitches meet, are called **hips**, and this type of roof is known as **hip roof**. As the building is not square, in this case, the pitch of the side $ao b$ is different from the pitch of aod , because the point o' , as seen in the plan (b), is the intersecting point of all four sides (called the *apex*) and is farther from f' and h' than from e' and g' ; therefore, the

proportion of rise to run is different in adjacent sides, and the pitches are necessarily different.

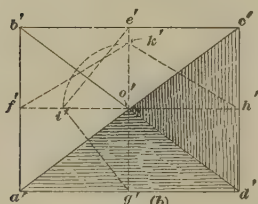
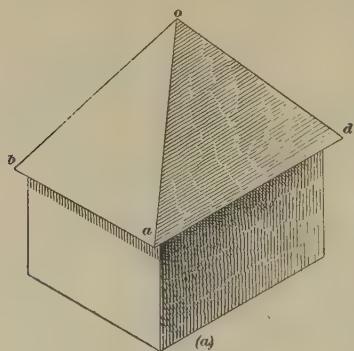


FIG. 47.

In the plan of this roof, shown at (b), the lines $a'c'$ and $b'd'$ show the position of the hips intersecting at o' . On the dotted line $o'e'$ is laid off the distance $o'k'$ equal to the height of the roof at the center o' , then the lines $k'f'$ and $k'h'$ show the pitch of the rafters, which are parallel to $o'f'$ and $o'h'$. Likewise when the height of the center point o' is laid off, equal to $o'i'$, the lines $i'e'$ and $i'g'$ give the pitch of the rafters over, and parallel, to $o'e'$ and $o'g'$.

136. In Fig. 48 we have the framing plan of a hip roof, where all four sides have the same pitch; being a parallelogram in form, its long

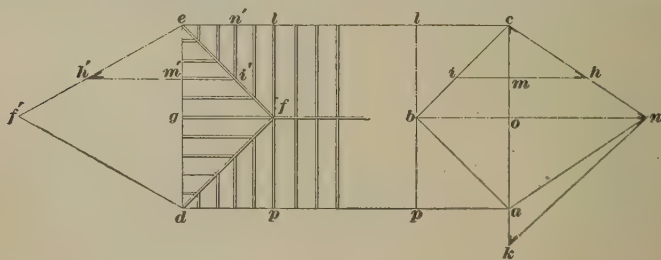


FIG. 48.

sides do not meet in an apex, as in Fig. 47, but form a ridge fb . If we lay off on the extended line of this ridge on equal to the height of the ridge above the plate, and

connect nc and na , we have, in the triangle anc , the outline of a vertical section of the roof through any point on the ridge line fb , and nc or na will be the pitch of the sides of the roof, as well as of the ends, as they are, in this case, both the same. The rafters between the points f and b will be parallel to lf , and their length will be equal to na , as will also the length of the two rafters fg and bo .

The bevel of the ends of these rafters, where they rest against the ridge fb , called the **plumb-cut**, is the angle cno , while the bevel on the other end, which foots upon the plate, called the **foot-cut**, will be the angle ocn . The four **hip rafters** fc , fd , bc , and ba will have a different length and bevel from those above named. This length and bevel are found as follows: Lay off ok perpendicular to go and equal to bc or ba , on plan, make on equal to the height of the ridge over the plate, and connect kn ; then kn will be the length of the hip rafters, the angle onk will be the bevel of the plumb-cut, and the angle okn will be the bevel of the foot-cut.

137. The short timbers, whose lower end rests upon the plate, while the upper end rests against the hip rafter, as shown at im , are called **jack-rafters**, and though they have the same plumb-cut and foot-cut as the ordinary rafters, they have an additional bevel on their upper ends called the **cheek-cut**, in order to have them fit nicely against the sides of the hip rafters, ba , bc , etc.

To find the length of a jack-rafter im , draw mh from the foot of the rafter perpendicular to co , and let it intersect cn , the roof slant, at h ; then will ch be the length of the jack-rafter, and the angles mhc and mch will be the bevels for the plumb-cut and foot-cut, respectively, which, as can be readily seen, are the same as for the ordinary rafters.

The **cheek-cut** of any jack-rafter may be found as follows: On the end of the roof, as at dc , draw the triangle $ef'd$,

making ef' and df' each equal to nk , the true length of the hip rafters; prolong the line of any jack-rafter, as $i'm'$, till it intersects the side of this triangle, as at h' , then the angle $m'h'e$ will be the cheek-cut for all the jack-rafters of that slope. If the slopes fg and fl are different, then to find the cheek-cut of the jack-rafters on the sides it will be necessary to erect another triangle on the side of the roof, making the base of the triangle equal to twice the distance el , and the sides, as before, equal to the length of the hip-rafter nk . Any jack-rafter, as $i'n'$, may then be extended until it intersects with the side of the triangle just described, and the cheek-cut obtained as before.

138. Figs. 49 and 50 are plans of a gable-and-valley roof, and a hip-and-valley roof, which, though differing somewhat in appearance, contain no constructive principle

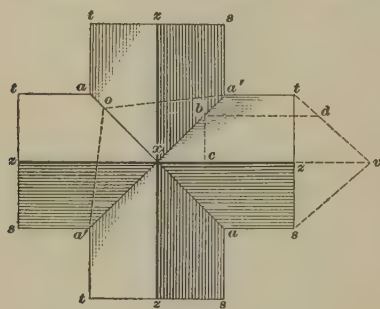


FIG. 49.

not existing in Figs. 46 and 47. The four gables tzs , Fig. 49, are precisely similar to the four gables in Fig. 46, but are brought forward from the sides of the square $aa'aa'$, giving the building the form of a cross, as shown. The dotted line zv is drawn equal to the height of the ridge zz above the eaves,

and the lines vt and vs are then drawn, giving the length of the rafters and their plumb-cut and foot-cut, as shown in Fig. 48. If on the valley line xa we lay off xo equal to the height of the ridge and draw oa' , then will oa' be equal to the length of the *valley rafter* under the valleys xa , and xa' , and the angles $a'ox$ and $oa'x$ will be the plumb-cut and foot-cut respectively. The length and cuts on the jack-rafter bc are found in the same manner as described in Art. 137, though the cheek-cut in this case is on the lower end of the rafter instead of at the top. If the lower end b of the jack-

emphasizes the break in the continuity of the roof plane.

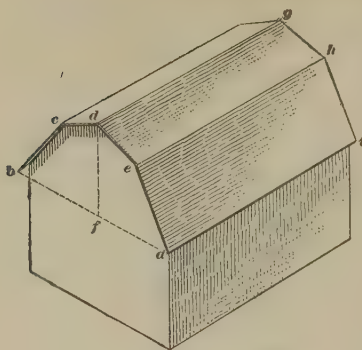


FIG. 51.

The ends of this roof are always of the gable form, as shown at $abcde$, but the slope from the ridge to the eaves is broken, the upper part cde being somewhat flat, and the lower parts cb and ea decidedly steep.

This form had its origin in the endeavor to provide a roof that would secure more space in the garret, or

attic, by increasing the height near the eaves, where a straight gable would give no head room. Its prototype is found in the *Mansard roof*, which was the invention of a Frenchman, whose name it bears.

The proportions of the example in Fig. 51 give the rise fd as equal to one-half the span ba , which is the common proportion of this form of roof; the pitch de should never be more than 30° from the horizontal, and the inclination ea should not be less than 60° .

In framing a gambrel roof it is always necessary to have a plate or curb at eh , as well as at ai , the rafters between them being cut to foot on ai , and to rest their plumb-cut against eh . The rafters between the ridge dg and the plate eh are cut in the same manner for ridge and plate as in an ordinary gable roof, the plate eh being securely tied across the building to keep it from spreading under the thrust.

141. The *Mansard roof*, sometimes called a curb roof, is shown in Fig. 52, and, as will be seen, it resembles the gambrel roof in having a very flat top $abcd$ and very steep sides $adfe$ and $d cgf$. Its points of difference, however, are equally prominent; for, while the gambrel roof has its ends always enclosed with gables, the *Mansard*

roof is always the same on all sides, therein somewhat resembling the hip roof.

The sides of the Mansard roof are generally, though not always, curved, and are much more nearly perpendicular than the sides of the gambrel roof, as, in reality, these lower slopes of the Mansard are nothing more than continuations of the side walls of the building. In fact, the distinguishing characteristics between the gambrel and the Mansard roofs may be said to be that the former is an endeavor to make the inside of the roof appear like an upper story, while the latter is an effort to make the outside of the upper story look like part of the roof.

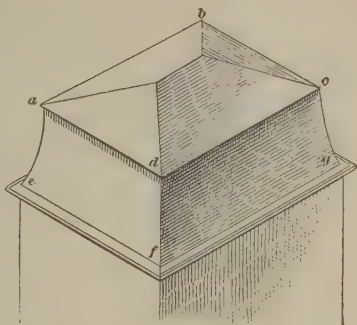


FIG. 52.

The relative pitch of the top and side slopes of a Mansard

roof may be determined in several ways, one of which, known as Belidor's method, is shown in Fig. 53.

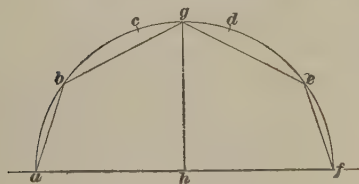


FIG. 53.

Upon the center h of a line af , representing the span of the roof, a semi-circle $acdfe$ is drawn and its circumference divided into five equal parts at a, b, c, d, e, f . By connecting ab and cf the pitch of the sides of the roof is obtained, while on connecting b and e with the ridge or apex at g , the proper slope for the top or summit slope is secured.

Variations from this rule are common in practice, but the above proportions are such as will usually give most satisfactory structural results.

142. In Fig. 54 is shown a plan (a) and the section (b) through the lower slope of a Mansard roof, while at (c) is shown the elevation of the angle rib at ae or df in Fig. 52.

In the plan (a) $u k'' x$ is a corner, or angle, of the building at

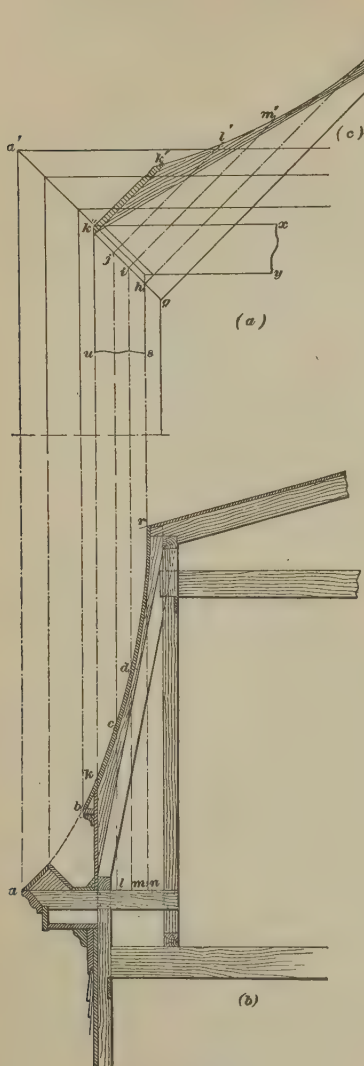


FIG. 54.

the lowest portion of the sloping sides of the roof, and is designated by k in the section (b). The line $s h y$, in the plan, is the upper edge of the sloping side, designated in the section (b) by r . If we now project up from the curved side in the section (b) any number of points, such as c, d, r , marking their intersections with the line $k'' g$, at j, i, h , and from these points, and at right angles to $k'' g$, lay off the lines $j l', i m', h n'$, equal to $c l, d m$, and $r n$ in the section (b), we have, at l', m', n' , points in the curve of the angle rib which, if connected by a curved line, will give the profile sought.

The distance $k'' k'$ on the angle rib (c) is the height of the point k , in the section (b), above the bottom of the main slope at a .

in the plan at z . The length of the rafters x to the cheek-cut is then found by projecting the points of intersection, of adjacent sides of x and y , to the top of the rafter in elevation, cutting the rafter at $p k$; $k c$ will then be the length of the rafters to the cheek-cut, as shown in the plan at x . The angle $c k p$ will be the plumb-cut for all the rafters in the roof.

144. The wall plate, shown in the elevation at s , is cut out of two thicknesses of 2-inch plank, each piece being long enough to receive the feet of four rafters. When the plate is built in position, it is laid up in two thicknesses, no two joints of which are to be in line perpendicularly, and the joints on the under side to be well supported by studs.

The under side of the rafters, where they project beyond the plate, is sometimes lined, or sheathed, with a board $t u$ called the **plancher**, or soffit, and the ends of the rafters at $e u$ are then faced with a board called the **facia**. The proper curvature of the edges of the plancher $d f$ is found by drawing the line $d g$ parallel to the inside of the rafter, and at a distance from it equal to the thickness of the plancher; this line will intersect the axis $b c$ of the roof at g ; then, with g as a center and radii $g d$ and $g d'$, describe the arcs $d f$ and $d' f'$, which will give the curvature required. The length of the plancher on the line $d f$ will, of course, be equal to the circumference of the roof at d .

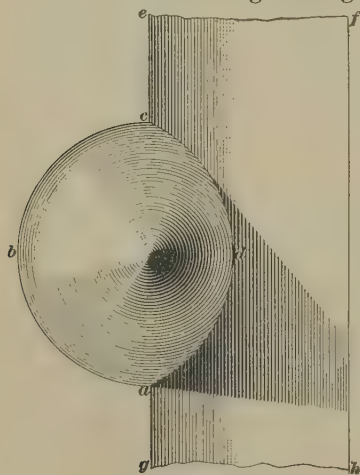


FIG. 56.

The roofing boards over the rafters are applied in the same manner as is described hereafter, in connection with the covering of domes, illustrated, subsequently, in Art. 205.

145. Where a conical roof intersects the pitch of another roof, it is necessary

to resort to particular framing in each case. Fig. 56 shows the plan of a conical tower roof abc , intersecting a flat single slope $efhg$, the line of intersection being the curve adc .

In Fig. 57 the plan A of the tower is divided into sixteen

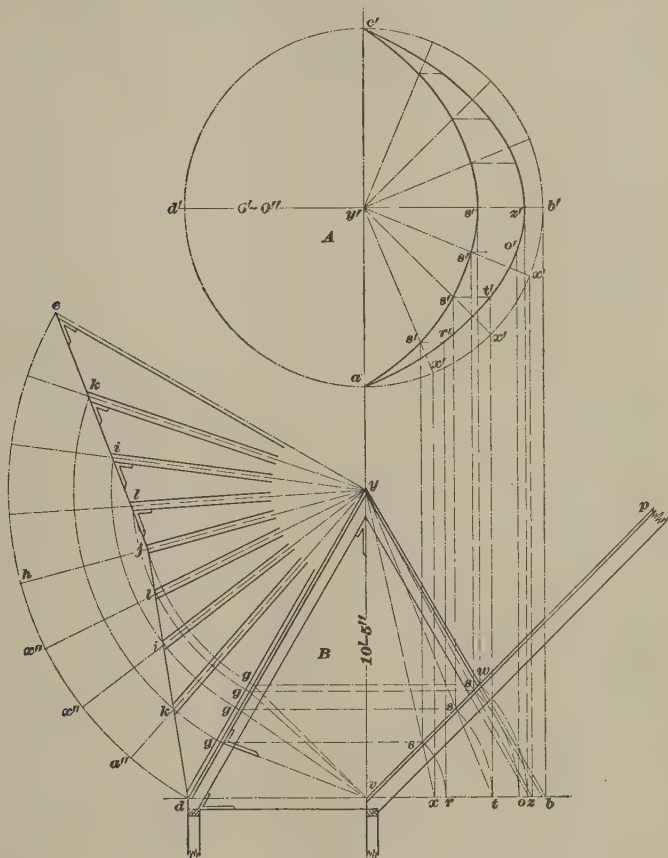


FIG. 57.

equal parts by the radial lines $y' a'$, $y' x'$, $y' b'$, etc., each one of which represents the center line of a rafter. The sectional elevation B shows the apex of the roof at y and the

rafters and their slopes at $y b$ and $y d$, while $d b$ is the line of the plate. The rafter $v p$ shows the slope of the main roof to which it belongs, and the point w shows the highest point in the line of intersection between the conical tower and the flat roof.

If we now draw the lines $y x$, $y t$, $y z$, etc., where the points x , t , and z are the projections of the points x' in the plan, these lines will indicate the position of the tower rafters in the elevation, and where these lines intersect the main roof slope at s , will be points in the curved line of intersection, between the two roofs.

Projecting the points s on each rafter to the plan of each rafter at A , we get the points s' , which are all in the line of intersection between the two roofs, as shown at $a d c$, in Fig. 56, and through which the line of intersection $a' s' c'$ can be drawn, in Fig. 57. Horizontal lines drawn from the points of intersection s to the outside of the rafter, or slope line $y d$, will give the length $y g$ of each of the rafters $y s$.

The plumb-cuts at y and the foot-cuts at d have already been described in connection with Fig. 55, but the foot-cuts of the rafters, where they rest on the surface of the roof $v p$, are found as follows: With y as a center and a radius $y d$, draw the arc $d h e$, on which space off the feet of the rafters, as at a'' , x'' , x''' , etc., and to these points draw radial lines from y . Make $y j$ equal to $y w$ the length of the shortest rafter, and draw $j c$ and $j d$; then the angle which $j c$ or $j d$ makes with the foot of each rafter will be the cheek-cut of that rafter on the roof, and a line $g v$ drawn from the foot of each rafter $y g$, will give the angle $y g v$, which is the bevel of the foot-cut of each rafter as it rests upon the roof $v p$.

The line of intersection between the two roofs, as shown in the elevation at $v w$, is seen in the plan A at $a' s' c'$, and being at an inclination, does not exhibit its exact curvature as it would appear if seen in a horizontal position. To find the points in the line of the true curve, proceed as follows: With v as a center with radii $v s$, describe the arcs $s r$, $s t$, $s o$, etc., and where these arcs intersect the line $d b$ erect the perpendiculars $r r'$, $t t'$, $o o'$, etc. From the points s' , in the

plan A , draw the horizontal lines $s'r'$, $s't'$, $s'o'$, etc., and where these intersect the perpendiculars just described, will be the points in the curve required, through which points the true curve $a'r't'o'z'c'$ may be described.

The advantage of finding this curve is that from it a paper templet may be made with the points $a'r't'o'$, etc. located on it, and the curve may thereby be marked out on the boards of the roof vp , and the rafters of the conical roof footed upon the points $r't'o'$, etc. with great exactness.

Where the tower roof djb is of large size, and is liable to throw considerable weight upon the main roof vp , short pieces of timber should be framed in between each of a pair of rafters where one of the tower rafters is to set its foot. On small towers the boarding of the roof is usually of sufficient strength in itself, and requires no timbers inserted beneath it.

146. A hexagonal roof and the system of framing it is shown in plan in Fig. 58, where the six hip rafters radiate from the center o to the corners of the hexagon $hfbg$, etc. The two pairs of rafters coj and goh should be set in place first, as in the conical tower, Fig. 55, and the other hip rafters are then fitted against them. To find the plumb-cut and foot-cut for these rafters, lay off oa equal to the height of the roof, and

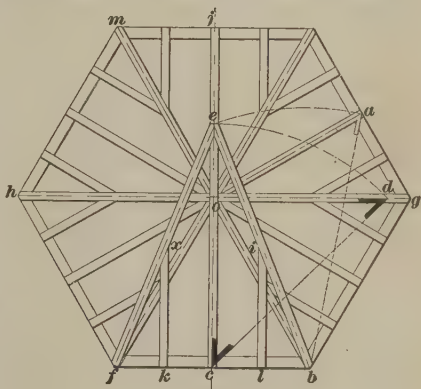


FIG. 58.

join a and b ; then the angle oba is the bevel of the foot-cut, and the angle oab , the bevel of the plumb-cut, while the distance ab is the length of the hip rafter.

The middle rafters oj , oa , oc , etc. are found by laying off

the height of the roof at od and joining d and c ; then the angle ocd is the foot-cut, and the angle odc is the plumb-cut on the rafters oj , oa , oc , etc., and their length is equal to the distance dc .

If from b we now lay off bc equal to ba the length of the hip rafters, and draw the lines eb and cf , on each of which, as a center line, the thickness of the rafter is laid off, we can draw in the jack-rafters kx and li ; then the angle fxk will be the bevel of the cheek-cut, and the angle odc will be the angle of their plumb-cut, which is similar to that of the rafter oc , to which the jack-rafters are parallel.

147. Sometimes a tower, or other small structure, is covered with a roof whose outline is composed of curved lines instead of the usual flat slope. This curved outline is usually compound in form; that is, one end is convex and the other is concave. When such a sloped roof is put upon a circular tower, it is called a **bell** roof, on account of its resemblance to the shape of a bell; but when applied to a square, or polygonal tower, we call it an **ogee** roof, from the fact of its outlines being of an *ogee*, or double curved, shape.

148. In Fig. 59 we have the plan (a) and sectional elevation (b) of the *ogee* roof of a square tower. The ribs, or rafters at and tb , shown in the plan (a), are either sawed or bent to the required shape, fitted squarely together at the top, and fastened in place. The ribs at $f't$ and $g't$ are next fitted, but are each shorter in length than the former pair by half the thickness of at or tb . The hip ribs lt , qt , mt , and rt are now put in place, and finally the jack-rafters oh .

To determine the length and curve of the hip ribs, or rafters lt , qt , etc., draw tx at right angles to lt and equal in length to the height of the roof cd ; divide the rib fd into any number of parts, by making points as at v , and from these points erect perpendicular lines vs parallel to dc ; where these lines intersect lt at s , draw the lines sx at right angles to lt , making sx in each case equal to the corresponding rv in the elevation (b); through the points v draw the

order that the boarding of the roof may have an even bearing on the angle rib, and the edges of the boarding must meet accurately on the center line of the rib mt . The amount of bevel required on the angle rib is found by drawing a line with a scratch gauge parallel to the upper edge, and at a distance mn below this edge; the wood between this line and the center of the top of the rafter is then cut away.

149. When two gables of different heights and spans intersect, the framing of the valley rafters is somewhat different from the case where both gables are the same height. Fig. 60 is the plan of a portion of a gable roof

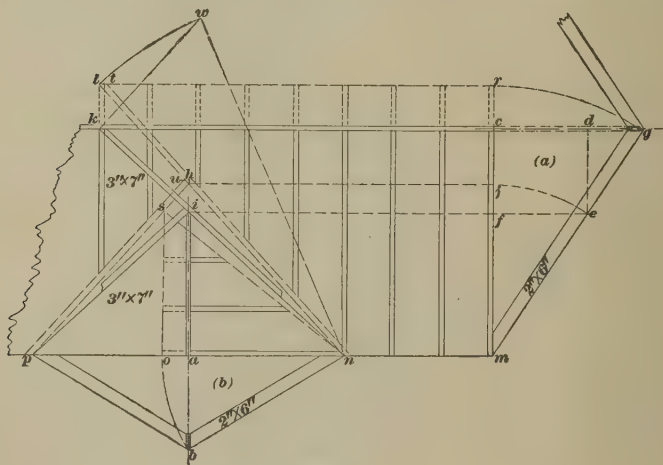


FIG. 60.

where a smaller gable at (b) intersects its slope. The inclination of the main gable (a) is laid off at gm , and the elevation of the end of the smaller gable (b) is drawn at pbn . The height ab of the smaller gable is laid off at cd and the line de is drawn parallel to cm ; ei is then drawn parallel to the ridge kc ; fe , therefore, represents the height of the smaller gable in comparison to the large one, and e is the

point of the slope where the ridge gable (*b*) will intersect; therefore, by drawing the ridge line *ai* of the gable, we intersect the line drawn from *e* parallel to the small main ridge at *i*, and the lines *ip* and *in* will, therefore, be the lines of the valley rafters of the small gable, as seen in plan. But, in framing our roof, we will carry one of these valley rafters *in* past the point of intersection *i* to the main ridge at *k*, in order that it may have a firm support at its upper end. The rafter *nk*, therefore, will have its plumb-check and foot-cuts the same as though the intersecting gables were of the same height.

The rafter *ip*, however, though cut at the foot with the same bevel as is *nk*, has a different cut at *i*. With *m* as a center and a radius *mg*, we strike the arc *gr*, and with the radius *me* we strike the arc *ej*; drawing *rl* and *jh*, *lrm* will be the plan of the roof on the flat surface, as though there were no pitch at all, the plan then shows the rafters at their true lengths and bevels. The rafter *nk* will, in this revolved plan, occupy the position *nl*, and *lt* will be its cheek-cut, while the rafter *pi* will now appear at *ph*, and *uh* will be the bevel of its cheek-cut. The plumb-cut of the rafter *nk* will be on the angle formed at *w* by making *kw* equal to *cg* and perpendicular to *nk*, and drawing *wn*; the bevel of the foot-cut will be the angle *wnk*.

The lengths and bevels of the jack-rafters in the main roof are shown in their true proportions in the revolved plan *lrm*, and can be scaled from that, while the necessary measurements for the jack-rafters in the small roof (*b*) can be obtained by revolving the pitch *nb* on *n* as a center until it lies on the level plane *no*. The triangle *osn* will then be the actual shape and proportion of one slope of the small gable roof, and the length and bevels of the jack-rafters can be scaled therefrom.

If the line *pn* from which the small gable springs should be, instead of at the eaves, as in this case, at some point on the slope of the roof above the eave line *pm*, the valley rafters *hn* and *hp* would be carried down to the plate, as at *u'* and *v'* in Fig. 72, in order to secure them a good footing, and

a piece of timber t' would be framed, from which the short rafters q' would extend to the eaves. Sometimes, when the main gable is very large and the smaller one is much less in size, the valley rafters are not carried down to the plate, as above described, but are simply framed into the nearest common rafter on each side and a rod is put through along the side of the piece which is shown framed at t ; this rod, when its nuts are screwed up tight on each end, prevents the common rafters from spreading under the thrust of the valley rafters framed against them.

150. It is sometimes desirable, in framing a roof, to make the rafters of very heavy material and space them much farther apart than in ordinary cases, as is always done when trusses are used in the roof.

In order to properly fasten the roofing material to these widely spaced rafters, it is necessary to introduce a series of small roof beams at right angles to, and with their ends resting on, the rafters. These roof beams are called

purlins, and though they possess neither plumb-cut nor foot-cut, they have a peculiar miter-cut, where they meet on hips or in valleys, illustrated in Fig. 61, in which $abcd$ is the plan of a roof with two slopes meeting on the hip db . From d we lay off de perpendicular to db

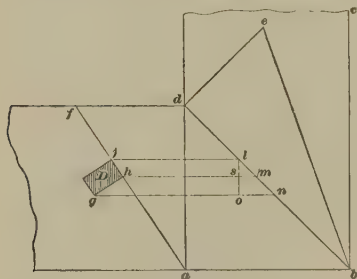


FIG. 61.

and df parallel to ab , and each equal to the height of the roof; then eb will be the slope of the roof over the hip db , and fa will be the slope of the roof over the common rafter da ; ghj is a purlin on the slope of the common rafters, and the dotted lines jl , hm , and gn show the position of the purlin in plan, and lmn the direction of its miter on the hip rafter db . The line lso is now drawn square across the plan of the purlin.

Fig. 62 is a perspective sketch of the purlin, where the line vx is drawn square across each side of the timber, and sr and xy are laid off equal, respectively, to sm and on , Fig. 61. The line vr is, then, the bevel on which to cut the miter of the purlin.

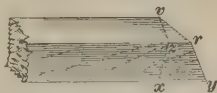


FIG. 62.

151. When rooms are divided in the attic, or under the roof of a building, and the partitions run neither parallel to the rafters nor to the ridge, the studs have to be cut at their upper ends to fit an inclined plane which passes over their diagonally opposite corners.

Fig. 63 shows at $abcf$ the plan of a stud, the sides of which are parallel neither to the rafter line ml , nor to the eave line li . The line kl shows the pitch of the roof over ml , to the plane of the under side of which the stud is to be fitted. The lines fj , ch , and bd , therefore, are the corners $fc b$ of the stud in elevation, and at jhd are the points where these corners intersect this roof pitch. By drawing dn at right angles to db ,

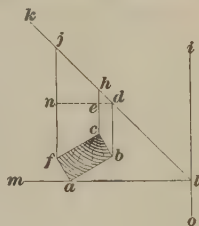


FIG. 63.

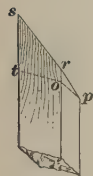


FIG. 64.

we find that the corner of the stud c is longer than the corner b by the length of the line eh , and the corner f is longer than the corner b by the length of the line nj . Therefore, if we draw a line around a stud, square with each edge, as top , in Fig. 64, and lay off ts and or equal to nj and eh , in Fig. 63, we have, on connecting the points srp , the bevel line of the end of the stud, as required.

THE USE OF THE STEEL SQUARE.

152. One of the most useful tools in the carpenter's kit is the **steel square**, as with it may be solved a number of problems which would otherwise require extensive drawings, or tedious calculations. Fig. 65 shows the regular form of this instrument; the length of the blade ac is always 24 inches, and that of the tongue ab varies, in different squares,

from 12 inches to 18 inches. The corner *a* where the blade and tongue meet, is called the heel.

153. In marking the plumb-cut or foot-cut on a rafter, where the pitch of the roof is known in the proportion of

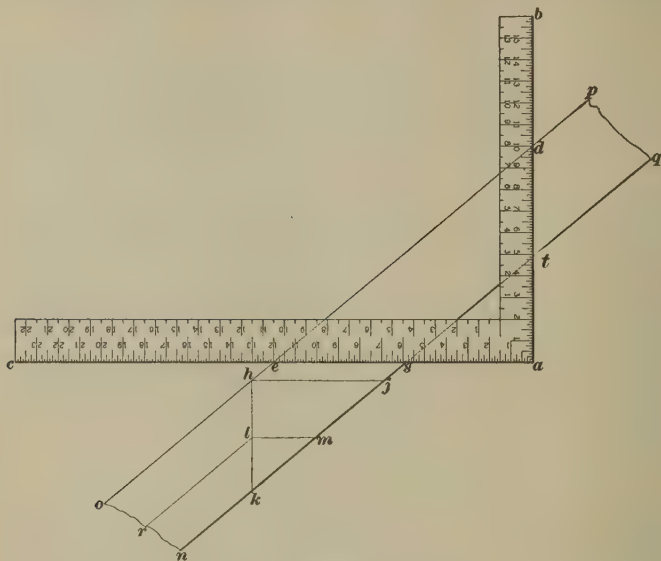


FIG. 65.

rise to run, it is only necessary to set the square upon the rafter in such a position that the *rise* in inches, as shown on the tongue, and the *run* in inches, as read on the blade, are both in line on the same edge of the rafter; the tongue will then mark the angle of the plumb-cut, and the blade will mark the bevel of the foot-cut.

In Fig. 65 let *no p q* be a rafter, the cuts of which are to be made for a roof in proportion of 10-inch rise to 12-inch run. The square is set so that the rise 10 inches is set off on the tongue at *ad*, and the run 12 inches is set off on the blade at *ae*; then the tongue will mark the plumb-cut *dt* at the ridge, and the blade at *es* will mark the bevel of the foot-cut at the plate. If the rafter is to project beyond the

plate, mark the foot-cut $h j$ and draw $h k$ at right angles to it. In the center of $h k$ draw $l m$ parallel to $h j$; then $k l m$ is cut out to notch over the plate, and the projection of the rafter beyond the plate is measured from h towards o . The length of the rafter may be determined by setting off the distance $e d$ along the top of the rafter, once for each foot of

half span in the roof, and the cuts at ridge and plate must be made from the ends of the rafter so determined. If the span is 24 ft. and the pitch is the same on each side of the ridge, the distance $e d$ is set off twelve times from the plumb-cut $d t$ to the top of the foot-cut h , beyond which the projection over the eaves is to be added, as explained above.

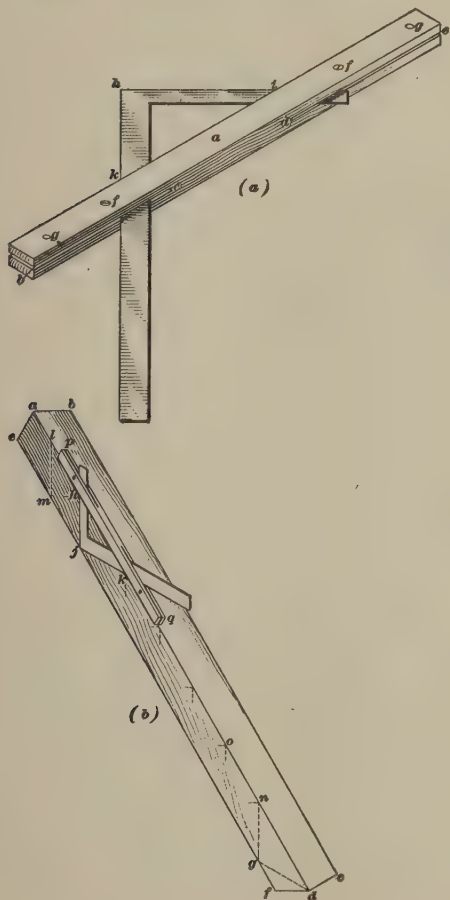


FIG. 66.

154. A very valuable appendage to the square is the simple device called a **fence**, shown at a in Fig. 66 (a). It consists of a piece of hard wood, preferably cherry or black walnut, 2 inches

wide, $1\frac{1}{2}$ inches thick, and 2 feet 10 inches long, with saw kerfs bc and de cut in from each end to within 5 inches of the middle, thus leaving 10 inches of solid wood at cd . Two holes f and g are bored through each end, and two $1\frac{1}{4}$ -inch No. 10 screws are then inserted, as shown at f , to bind the fence on the square.

The purpose of the fence is to do away with the use of the bevel in laying roof joists, angle beams, stair strings, etc. In the above case the fence can be set for the rise of the rafter at hi and the run laid off at hk ; then, if the fence and square are applied to the scantling, as shown in Fig. 66 (*b*), the tongue will show the plumb-cut lm and the blade will give the bevel for the foot-cut gd .

In Fig. 66 (*b*), let $efcdfe$ be a rafter and hjk a steel square with the fence pq applied for the proper rise and run of the roof. The fence and square are then placed at the lower end of the joist, and the line gd is marked for the foot-cut. At the same time the point n is marked on the scantling at the point h of the square. The fence is now slid along until the point k on the square coincides with the mark at n on the rafter, and the point h on the square is then marked at o on the rafter. This operation is repeated once for every foot of run in the roof, as shown by the dotted lines; then the last position of the tongue at lm will be the plumb-cut of the rafter, and the distance ld will be its top length.

CONSTRUCTION OF ROOFS.

155. In building the roof on a house, the rafters are nearly always carried beyond the front of the plate from 10 to 24 inches, in order that the drip from the eaves may fall clear of the wall of the house. Fig. 67 shows the method of cutting the rafters where they so project, and also a method of finishing and enclosing the rafters, and of forming a standing gutter.

A rafter $abefdc$ is notched over the plate g at cd and projects beyond the plate at df . The portion of the rafter below df is cut away to lighten the appearance of the eaves, and the line on which to cut the rafter for it is shown at mlr , Fig. 65. At h is a tie-beam, which is spiked to the

ends of the rafter on each side of the building, and, in this case, forms, also, the ceiling beam of the upper story and rests on the plate *g*. From the top of the tie the rafter is closely boarded with 1-inch boards *k*, the lower one of which is allowed to project about half its width beyond the end of the rafter at *e i*. The end of the rafter is cut on the line *e f*,

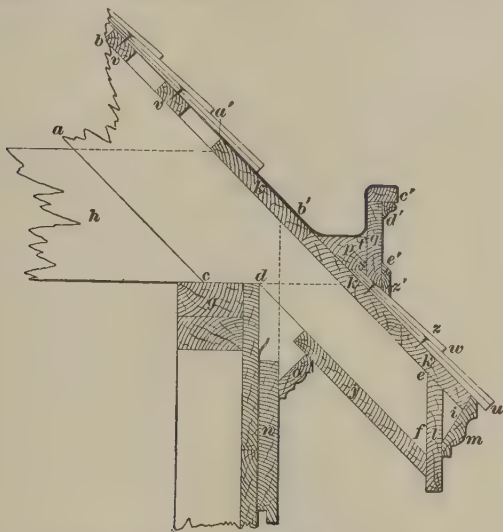


FIG. 67.

which is parallel to the plumb-cut at the ridge, and the soffit, or plancher, *j* on the bottom of the rafters has its outer edge beveled to the same angle, as is, also, the top of the facia *l*, which finishes the ends of the rafters. A crown molding *m* is then secured in place by nailing it to both the projecting roof-board *k* and the front of the facia *l*. This gives a finish to the projecting eaves, and the under side is completed by the insertion of the molding *o* between the soffit *j* and the frieze, or top casing, *n*. This finish is usually called a box cornice, in that it is formed by a boxing, or casing, of wood. Over the roofing boards, and outside the line of the front of the building, a bedplate *p* is nailed securely to each rafter, to form the gutter, as will be explained further on.

156. Roofs are variously covered with wood shingles, steel shingles, slate, tin, lead, zinc, corrugated iron, copper, or tiles. A flat roof should always be covered with tin, copper, or other material which is practically one piece, as water will run back between the joints of shingles, slates, or tiles, and thereby get into the interior of the building. A pitched roof may be covered with any of the above materials, but generally shingles, slate, or tiles are used.

157. Shingles are laid on the roof of the house, either upon sheathing boards, as shown at *k*, Fig. 67, or upon shingle laths, as shown at *v*. The latter method is preferable, as it gives better ventilation to the under side of the shingles and prevents the accumulation of moisture there. When boards are used as a roof covering upon which shingles are to be laid, they should not be laid close, as at *k*, except over the eaves. Shingle laths, shown at *v*, are usually $1\frac{1}{4}$ in. $\times$ 2 in., or $1\frac{1}{4}$ in. $\times$ 3 in., and are laid at right angles to the rafters, and from 4 inches to 8 inches on centers, according to the exposure of the shingles to the weather. The amount of this exposure also determines the length of shingles which can be used with the greatest economy of material consistent with first-class work.

Shingles vary in length, and can be obtained in regular sizes of 16 inches, 18 inches, 24 inches, and 27 inches in length, and from 4 inches to 7 inches in width. The size to be used in each case should be about 3 inches longer than three times its exposure to the weather.

The first course of shingles is laid at the eaves, and is laid double with broken joints, as at *u*, Fig. 67, in order that water finding its way through the joints of the upper layer, may not readily percolate through the lower layer and rot the roofing boards, fascia, etc.

When the first course is laid, each shingle is nailed with two nails about 2 inches above the upper line of its exposure; the amount of exposure is then measured back from the lower, or butt, edge of the shingles, and a line is struck by means of a chalked cord, to which line the butts of the next course are laid, as at *w*. This protects the nails driven

in the previous shingles by the 2-inch lap shown at zw , and the nails of the second course pass, also, through the upper ends of the first course, as at z' .

158. After the shingling is completed up to the gutter plate p —which, in this case, requires but two courses—the gutter face board q is set in place with its lower edge beveled to fit the top of the shingles; a plinth c' , a cap member c' , and bed mold d' , may now be nailed in place.

In lining the gutter with copper or tin, it is well to nail a strip of hoop iron along the edge of the cap c' , allowing the lower edge to project below the cap. To this edge the metallic lining may be clasped, from which point it extends across the bed of the gutter to b' and up as far as a' .

In starting the course of shingles above the gutter, care must be taken that the butts are placed somewhat higher than the overflow of the gutter, so that they will be clear of the water when the gutter is choked; it is well to have the metallic lining extend for 5 or 6 inches under the shingles. When the first course of shingles above the gutter is laid, the course is doubled for the same reason that it is at the eaves, and the remainder of the roof from here up to the ridge is shingled, one course at a time, as explained above.

159. Another form of gutter is shown in Fig. 68, where the end of the rafter is cut out at abc , and a short piece of timber d is spiked on the side of the end, as shown, to form the front edge of the gutter depression, while the back of the gutter is formed with a piece of $1\frac{1}{8}$ -inch plank spiked on the end of the rafters at ab .

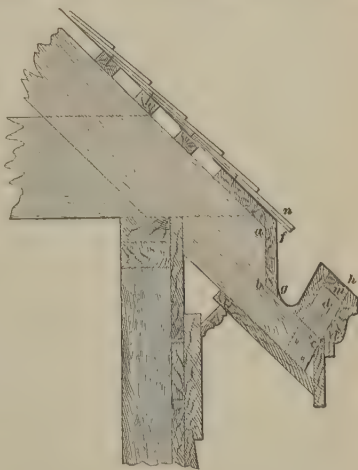


FIG. 68.

The lining of the gutter or flashing *f g h* is then bent in place and turned over the roof-board *m* and around the fillet of the molding *l*, where it is held in place by being clasped to the edge of a strip of hoop iron, previously attached to the fillet. The back of the lining is turned under the shingles at *f* and the first course of shingles *n* is laid so that the butts project 1 inch to $1\frac{1}{2}$ inches over the edge of the gutter.

This form of gutter is generally invisible from the ground and permits an uninterrupted slope to the roof from the ridge to the eaves, so that accumulated snow may slide off without hindrance, and free the roof of its weight and dampness. It is objectionable, however, in some cases where the eaves project considerably, as will be shown further on, and if it is built up closer to the plate, or above the plate, it materially weakens the rafter. The necessary slope, or fall, of the gutter, in order to cause the water to flow towards the leader end, is accomplished, in this case, by cutting each succeeding rafter slightly deeper than the preceding one.

160. The lining of a gutter should be of the best quality of material, with all the joints properly folded, if of tin, and well soldered. It should be painted on both sides and well fitted to the gutter. The gutter plate *p*, Fig. 67, is made of a varying width so that the gutter has a gradual pitch towards the **leader**, or outflow pipe, which is located at the lower end. This leader is usually made of tin, corrugated galvanized-iron, or copper pipe from 2 inches to 6 inches in diameter, according to the size of the roof it must carry the water from; and where the roof area is very great, more than one leader may be necessary to carry off the accumulation of water during a heavy rain. A liberal allowance is to provide 1 square inch of leader section for each 75 square feet of roof area; but never to use a leader less than 2 inches in diameter. Even that size is liable to become choked and clogged with dirt or leaves, if in a wooded section of country, and should be used only for veranda, porch, bay window, and other small roofs.

The leader is inserted through the bottom of the gutter

and its metallic lining, and must be well soldered to the latter, while its **throat**, or inlet, should be countersunk, and protected with an open iron grating, or wire screen, to prevent foreign substances from entering with the water.

161. **Flashing** is a term given to all sheet-metal work used in connection with roof covering to insure a water-tight condition at joints and angles. Flashings are required on hips, valleys, ridges, and eaves, around scuttles, skylights, gables, flanks of dormer-windows, etc.

162. On hip roofs, where angle rolls are not used, pieces of flashing are laid on the *hip* over each course of shingles or slate in the same manner that a shingle or slate itself would be laid, if it could be bent to fit around the corner as shown at *a*, Fig. 69. For, while the joints between the various pieces of roof covering may be broken, or alternated, as at *b*, in the main flat slopes, the hips must have a continuous row of joints from the eaves to the ridge, as at *c*, and the insertion of flashings under the shingles, at these points, prevents the water that would work its way beneath the covering from getting into the interior, and carries it to the flat slopes, where it may harmlessly run off.

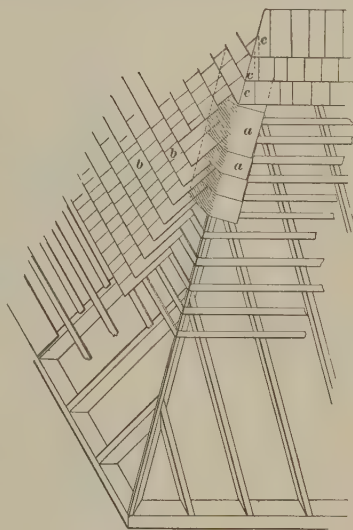


FIG. 69.

163. In valleys the means adopted are different, as the conditions are in some respects reversed. On the hip of the roof there is no accumulation of water at any time, and what little may fall there is immediately drained off by the

pitch; but in the valley we have a depression between two slopes, and all the water falling on each of them is immediately carried to the valley.

The valley, therefore, acts in the capacity of a gutter, and is flashed accordingly. The tin is joined, generally at the ends, to form a continuous gutter in the depression, and its edges are turned up under the shingles about 6 inches. The shingling is not carried down to the intersection of the slopes, but is stopped about 5 inches from the valley rafter, and the gutter, thereby, is left open. The flashing of all such situations will be treated in detail in *Sheet-Metal Work*.

164. Along the ridge the roof is rendered water-tight by a number of different methods, two of which are illustrated in Fig. 70,

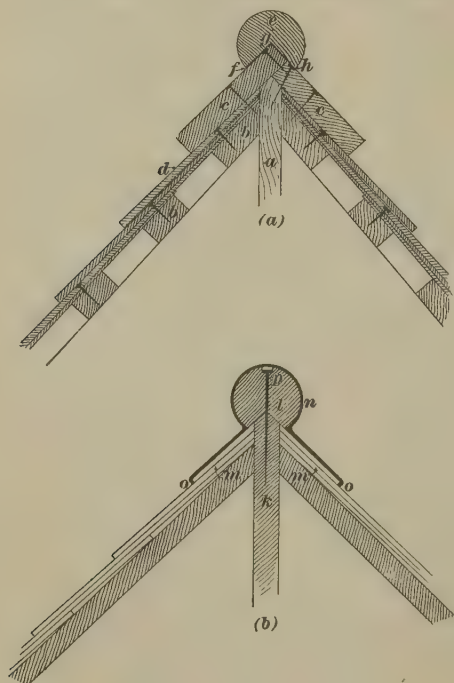


FIG. 70.

(a) and (b). At (a) is a method used on a shingle roof and requires no flashing, while at (b) a metal flashing is used on a slate, or flat tile, roof. At (a) the ridge plate *a* is carried above the line of the shingle lath *b* and the top of the shingles *d*, and its top is beveled off to conform with the general pitch of the roof. After the shingling is complete, the top of the ridge is finished off to form a continuation of the

top surface of the last course of shingles, and the **ridge boards** *c* are nailed to it and to each other in the position shown. Before the ridge boards are nailed in place, there should be a layer of two-ply roofing felt folded over the ridge, on top of which the ridge boards may be firmly nailed; this will tend towards making a thorough water-tight job. These ridge boards are usually from 1 inch to $1\frac{1}{8}$ inches in thickness, and from $5\frac{1}{2}$ to 9 inches in width, according to the amount the shingles are exposed to the weather. The **ridge roll** *e* is formed from a single piece of wood, is from $2\frac{1}{2}$ to 3 inches in diameter, and is *rebated*, or *rabbeted*, at *fgh* to fit the angle at the top of the ridge boards; this **V-shaped** groove, or rabbet, should be deep enough to permit the edge of the roll *h* to lap well over the joint between the two ridge boards *c*.

At (*b*) the slating of the roof *m* is carried up to the beveled end of the ridge plate *k*, butting against it as the shingles do in (*a*), and the wooden ridge roll *l* is rabbeted over the joints formed at the ridge and the ridge plate. This roll is held in place by long spikes *p* driven through its top into the upper edge of the ridge plate, and over it is sprung the galvanized-iron covering *n*, which has been previously shaped to fit the roll and catch the under edge of the last course of slates, as at *o*.

Ridges, like hips, are very slightly subject to leakage, and, as little water falls on them, and practically none remains after it has fallen, we do not require the same precautions with flashings at these points as we require elsewhere.

165. Around skylights and dormer-windows, where the sill rests on the slope of the roof, flashing is applied so that it extends under the roof covering which is adjacent to the sill, and turns up and over the sill itself in such a manner as will prevent any possibility of water working its way between the sill and the slate or shingles. The sides of a dormer, where they intersect with the roof pitch, are flashed in the same manner as are the valleys, except that the

shingling or other covering may be carried up close to the finished sides.

166. Great care must be observed along the eaves of a roof, especially where that roof is over a well heated room, as the interior heat will, during the winter, cause the snow on the roof to melt and run to the eaves, where, relieved from the effects of the high temperature, it freezes and builds up a dam of ice, and the accumulated water backs under the shingles and gets into the house. Under these conditions it is sometimes desirable to build the gutter above the line of the plate, in order that the same heat that melts the snow may sufficiently warm the gutter to prevent it from freezing up when its services are most needed.

Unless the pitch of a roof is at least 45 degrees above the horizontal, there is much danger of leakage during windy weather, as a high wind will drive the water under the shingles and through the first crevice that presents itself. Hence, the importance of exercising the greatest care with all the flashings, and of securing broken joints in each course of shingles.

Shingles with loose knots or open knot holes within half their length of the butt, or shingles that are split, or shaky and liable to split, should be rejected, and rejected shingles should be broken or cut through with the hatchet, lest some other workman, with less precaution, be inclined to use them. The slight apparent waste thus caused is nothing compared with the expense and inconvenience of a leaky roof.

DORMER-WINDOWS.

167. **Dormer-windows**, a term applied to windows projecting from the roof of a building, are framed out when the roof is constructed. The size and the shape of the openings left for them between the rafters, depend upon the size and the character of their roofs.

Where a dormer-window is covered with a small gable, the main roof is framed for it in the manner described in Art. **149**, and where the covering is a flat pitch, somewhat

like the lean-to roof in Fig. 44, the opening in the rafters is left rectangular, with a header and a pair of trimmers, as was described in Art. 110, except that the header and tail-beams are not usually mortised and tenoned into the timbers to which they are joined. The sides of dormers are studded and sheathed in the same manner as the outside walls of the house.

168. Sometimes these roof openings are very small, and introduced as much for ornament as for light or ventilation; this is particularly the case in the form known as the **eyebrow window**, shown in Fig. 71, in which (*a*) is its front elevation and (*b*) a sectional side elevation through the center of its roof. This elevation shows the curvature of each of the ribs *b*, *c*, *d*, etc. of the front elevation by the dotted lines *b'*, *d'*, *e'*, etc.

The example shown in Fig. 71 is 9 feet in length from *g* to *h*; the line *gh* is the top line of the main rafters, as shown at *g'*, while the line *sr* is the top line of the roof sheathing, shown at *s'*. The height *jp* is 2 feet and the curve of the front elevation of the roof *spr* is formed with three arcs of circles, whose centers *tt* and *k* are located as follows: Prolong the center line *pj*, and with some point *k* as a center, describe the arc *upv* with such a radius that the points *u* and *v*, where this arc intersects the lines *pr* and *ps*, will fall below *p* less than half the distance *pj*. Then from *k* the center of the above arc, draw through the points *u* and *v* the lines *kt*, and the points *tt* where these lines intersect *rt* and *st*, drawn perpendicular to *sr*, will be the centers for the arcs *ur* and *vs*, which complete the compound curve of the top of the window. All the curved parts of the elevation are described from these centers, the arcs above the lines *kt* being described from *k* as a center, and those falling below the lines *kt* being turned on *t*, *t* as centers. The ribs, or rafters *a*, *b*, *c*, *d*, and *e*, are now spaced off to stand about 9 inches on centers, and, as will be observed, the top and bottom edges will be beveled to conform more closely to the curved outline of the roof, except the middle rib *a*, which is, practically, rectangular in section.

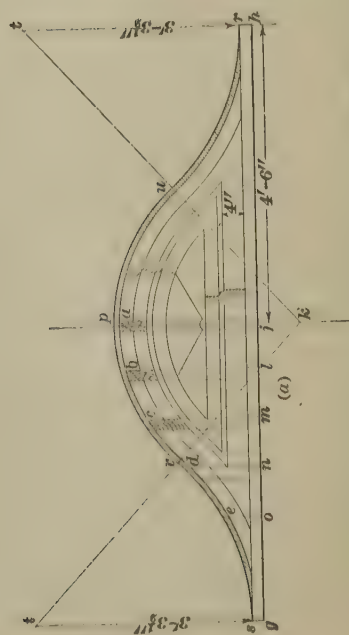
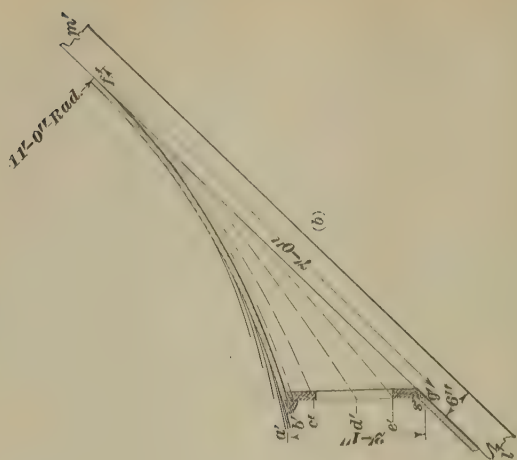


FIG. 71.

In the section through the center of the window shown at (b), a' , b' , c' , d' , and e' are the ends of the ribs, shown at a , b , c , d , and e in the front elevation (α), and the lines $f'a'$, $f'b'$, etc. are the tops of these ribs and the profiles of their curvatures. The rafter $l'm'$ shows the pitch of the main roof, and the roof of the eyebrow window curves upwards towards it until it becomes tangent at f' . All the ribs $a'f'$, $b'f'$, $c'f'$, etc. become tangent at f' , and the bevel of their top and bottom sides, shown in the front elevation (α), gradually diminishes as they recede, until at f they are all rectangular in section. The curvature of the ribs, as shown by the dotted lines $f'c'$, $f'd'$, etc., is determined by striking the curve of the uppermost rib with the arc of a circle, whose radius must be perpendicular to the rafter $l'm'$ at f' , and the distances $g'e'$, $g'd'$, $g'c'$, etc. are laid off to correspond with oc , nd , mc , etc. in the front elevation. From each of the points e' , d' , c' , etc. is then drawn the top line of the rib to f' , varying the curvature in each successive rib to such a degree as will keep them the same relative distances below one another as at their starting points a' , b' , c' , etc. The ribs are sawed out of 2-inch plank on lines developed as above described, and the shingle lath are bent over the curve and continued on the main roof without interruption, as the curved outline of the window removes all necessity of valleys, and, consequently, of flashing.

When the roof is shingled, the lines of the shingle butts are carried along over the eyebrow window, so that, in reality, it forms simply a protuberance of the main roof.

169. Windows of the same general character as the eyebrow window, are sometimes constructed with a flat, square roof, curving upwards slightly as it recedes towards the main roof, so that the side elevation and section are similar in shape to (b); but the ribs forming the roof construction are all alike and rest on a straight plate in front, while the sides are shingled, or sheathed, in the same manner as a dormer-window.

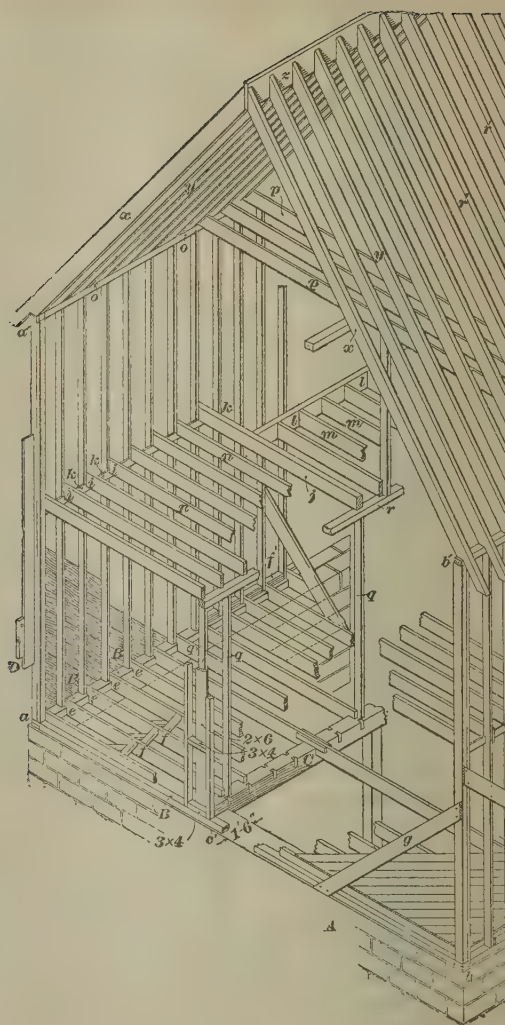
BALLOON-FRAME CONSTRUCTION.

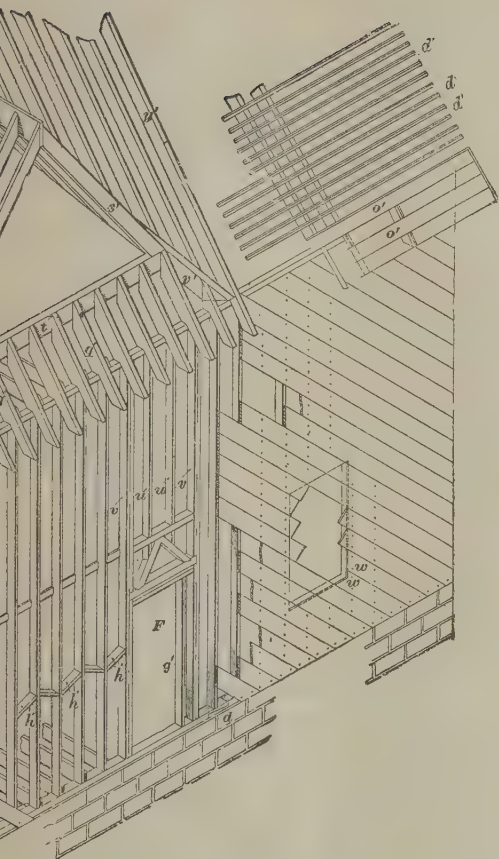
GENERAL DESCRIPTION.

170. Balloon framing, as heretofore explained, is the term given to that system of construction in which the skeleton, or framework, of a building is spiked together with butt joints, and depends almost entirely for its strength and stability upon its exterior covering and the manner in which this covering is applied.

We will now take up the construction of a balloon-frame building, applying, as we proceed, such methods and means as have already been set forth in these pages, and studying, as they appear, such new or additional features as the necessity or the economy of the construction demands.

171. In Fig. 72, *A* is the stone foundation wall, 1 foot 6 inches in thickness. On top of the foundation wall is spread a bed of lime mortar at *c*, in which the sill *B* is laid and well bedded by means of repeated blows from a heavy hammer. When this is done, the outside edge of the sill, which is kept back 1 inch from the face of the wall, is pointed up; that is, the joint between the sill and the top of the wall is carefully scraped off to give it a neat, even finish, and any surplus mortar is removed from the 1-inch projection of wall. The plate is halved and spiked at the corners in the manner described in Art. 82, as shown at *a* and *b*, and where the pieces composing it cannot be obtained in sufficient lengths, the sill is pieced out by means of the beveled splice, as shown at *d*. In exposed situations where high winds are frequent, it is not uncommon to anchor the sill to the wall by means of anchor bolts. These bolts are from 1 inch to 1½ inches in diameter, and are firmly built into the mason work of the wall with the thread end projecting above it. Holes are then bored in the sill to fit over these projecting ends, and, after the sill is laid and leveled, it is securely held in place by screwing nuts tight on the ends of the bolts with a washer between each nut and the sill.





172. After the sill is set in its place, leveled, and its angles squared to be absolutely true, we may proceed to lay the first tier of floorbeams. These are notched over the sill to bring their tops to a level line, as shown in Fig. 30, or, where great economy of material is to be desired, the beams are notched 4 inches or more to bring their under sides flush with the bottom of the sill, where they are bedded in the same mortar topping of the foundation that the sill itself is, or the beams are blocked up on top of the wall with pieces of slate. But in all cases where they are so deeply notched *the floorbeams must have a solid bearing on the wall*, as shown at *e*, Fig. 72.

Where the span is so great that the beams must have an intermediate support, a brick wall, or a girder, as shown at *C*, is carried through the center of the house and is supported on posts. A brick wall is better for the purpose than a girder, for, when built up to the same height as the foundation walls, and capped with a wood sill of the same thickness as the main sill, we have the same amount of shrinkable material in all the supports of the first-story beams and partitions. Where a girder is used, however, we must take precautions to equalize, as nearly as possible, the effect of its shrinkage with that of the main sill. This is done by notching the girder, as shown, and by notching the beams in the same manner as at the sill, so that the solid portion of the girder below the notches is equal in thickness to the depth of the main sill of the house.

Great care is required in cutting these joints to insure a good seat, not only for the beam on the bottom of the notch, but also for the projecting tenon of the beam on the top of the girder; too much weight on the notch would tend to split the girder, while too great a strain on the tenon would tend to split the beam. It is for this reason that in strictly first-class work the beams are simply sized over the main sill, and their inner ends are similarly sized over an interior sill supported on a brick or stone wall.

Whether they meet on a girder or wall, the ends of the beams should be huddled together, and held by cleats nailed

on each side; they should never be lapped one beam on the side of the other and spiked together, as this produces irregularity in the beam spacing, and makes the subsequent laying of hot-air pipes, etc. very troublesome. The floorbeams having been spaced and securely nailed along sill and girder at the uniform distance of 12 inches or 16 inches on centers, they are then cross-bridged, as shown at *f*. See Art. 109.

173. While this bridging is in progress, or even before it is commenced, the side walls of the building are started, by setting the corner posts *a a'* and *b b'* in position. And after they have been carefully plumbed with a level and straightedge, as shown at *D*, or preferably by a long plumb-rule and blumb-bob, they are braced in position by two pieces of sheathing nailed securely to the posts and to the sill, as shown at *g*.

The corner posts are generally composed of two pieces spiked together, as shown at *a b'*, in Fig. 37, and the larger piece is sometimes, though not always, mortised or doweled into the sill.

174. After the corner posts are secured, the studs are spaced along the sill 16 inches on centers and are spiked both to the sill and to the floorbeams; they are then plumbed and carefully alined along the outside edge of the sill, and secured in place with braces similar to those of the corner post, those on the exterior being permanent in the form of sheathing, while the brace extending from the side of the stud to the floorbeam is but a temporary affair, to be removed as soon as the interior partitions and the second-story beams are in place.

These studs and corner posts are all cut to an even length on the ground before they are set in place, and at the same time the notches for the ledger boards *k* are cut in the studs 4 inches wide and 1 inch deep, and as soon as the studs are set in place, the ledger board itself is fitted and spiked to each stud with two nails.

On this ledger board the floorbeams *n* of the second story

are laid, each beam being slightly notched at *i*, on its under side, in order to bring the tops of the beams to an even alinement. The second-story beams are not nailed to the ledger board, but are securely spiked to each stud, on the same side of the stud as the beams in the tier below.

175. The beam shown at *j* is double the thickness of those at *n*, as it is a trimmer beam and carries the header *l* and the weight from the tail-beams *m*. This header and trimmer forms one end of the stair well, or opening, and if there is to be a similar opening in the third, or attic, floor, great care must be taken to place the attic-floor header perfectly parallel and plumb over this one, as trouble will arise when the stairs are built unless such care is observed.

176. The second-story beams being laid, we may now start the tier above, but if this third tier is simply to be of ceiling beams, and the attic story is not to be finished off in rooms like the rest of the house, we will first lay the wall plate *o*, which is usually composed of two pieces of studding nailed together and so lapped that the joints of any two lengths are as far apart as possible.

This plate is laid along the top of the wall and securely nailed to each stud; the attic beams are then notched over it in the same manner as the first tier of beams was notched on the sill, and securely nailed in place.

Our exterior frame is now fairly complete from sill to plate; and while the above described work has been in progress, the partitions have been erected, the first, or rough, floors laid on the interior, and the window and door openings framed, and the frame sheathed in, on the exterior. In fact, it is sometimes necessary to erect the main partitions at the same time as the outside walls, in order to provide a support for the interior ends of the floorbeams.

177. The studs *q q*, supporting the partition plate *r*, show the position of a principal partition which supports the ends of the second-story beams *m* and *n*, and the continuation of this partition in the second story supports the interior ends of the attic beams *p*.

The plate *r* on the top of these stud partitions is generally composed, like the main wall plate *o*, of two pieces of studding nailed together, and though one thickness would be strong enough for all practical purposes, the two pieces are preferable in order to secure the same amount of shrinkable material under each end of the beam, and as the ledger boards on the outside are 4 inches deep, the plate in the interior is made 4 inches deep, also.

178. The *framing of the openings* is shown at *E*, where the studs on each side of the opening are doubled and spiked securely together to act, practically, as one piece. The head and sill of the opening, if it is a window, are also composed of doubled studs, and where the window is over 3 feet in width, the top should be trussed, as shown at *s*, and described in detail in Art. **129**. The double studs at the sides of the opening are carried through to the plate, and if there are to be two openings, one over the other, the upper one alone need be trussed, unless there are floorbeams, or other details, which will concentrate too much weight over the opening. This is the case at *E*, and the window head is trussed to carry the load of the two beams *t* to the double studs at the sides.

179. In laying out the studding of the exterior walls of a building, two methods are used; one where the double studs at the sides of the doors or windows are first placed in position, and the single intermediate studs are spaced 16 inches on centers between them; and the other method, in which the studs are spaced throughout at the uniform distance of 16 inches on centers, after which the door and window openings are sawed out and the studding framed to suit.

The former of these methods is shown at *E* and the latter at *F*, where two studs *uu* have been cut out and the adjacent ones *vv* have been doubled, the space between them being trussed to carry the floorbeams in the same manner as at *E*. This leaves an opening of 4 feet between the centers of the studs at the sides of the opening, and, as this is more than

we require, we limit the opening by the stud *g'* cut in between the truss and the sill; or, if the plan requires the door to be further to the right, we can cut in two studs and center the opening at any point desired.

180. **Sheathing** is composed of $\frac{7}{8}$ -inch boards, matched or unmatched, and planed on one side to give them a uniform thickness. In balloon-frame buildings *they should always be laid diagonally*, as it is upon the bracing effect of the diagonal sheathing that the building depends for its strength. When the corner posts of a building are set and plumbed, two pieces of sheathing are then nailed on its adjacent exterior sides with their lower ends spiked to the sill, as shown at *g*, and as the studs are successively set they are braced on the outside by similar sheathing boards, and every sixth or eighth stud is braced temporarily from behind, as shown at *h*. The sheathing is then carried over the whole side of the building, no attention being paid to door or window openings, except where a sheathing board projects a few inches over an opening; it is permitted to remain so, and the next board to it in the course is started from the other side of the window.

This is illustrated at *G*, where the dotted lines show the outlines of the window opening, and the full lines indicate the sheathing boards as they are laid up on the studs, to each one of which they are nailed with two tenpenny nails. At *w* is shown the sheathing sawed out to fit the opening, the boards being cut flush with the face of the studs.

181. When the sheathing is nearly completed and the first, or rough, floors are laid, the structure is ready to receive the first timbers of the roof.

The pitch of the roof in this case is rather steep, being 17 inches rise to 12 inches run, and the plumb-cut of the rafters will be found by laying the steel square on the side of the timber with 17 inches of the blade and 12 inches of the tongue on the line of what is to be the top edge of the rafter; the outside line of the blade will then mark the plumb-cut, as explained in Art. **153**. The foot-cut and overhang for the eaves are measured and cut as explained in Art. **153**,

and when one rafter is finished and sawed complete, it is used as a templet to mark and cut all the others by, before the framing of the roof is commenced.

The first rafters set are those forming the end of the gable at x , and the ridge plate z is composed of a wide piece of $1\frac{1}{8}$ -inch material beveled on its upper edge, as explained in Art.

164. To this ridge plate the rafters x are spiked on opposite sides, and somewhere near the other end two other rafters are similarly spiked to hold the ridge plate in position. The rafters y and y' are so placed as to foot on the plate o adjacent to the valley rafters w' and v' , which are then placed in position, having been previously cut to the required lengths. The valley rafter w' is set first, and then the valley rafter v' is securely footed on the plate and spiked against it. The header plate t' is then spiked between these two valleys at the point where the slope of the smaller gable is to start, and after t' is securely nailed to the two valley rafters, the first two of the small gable rafters s' may be set in position, securely nailed to the header plate t' and spiked through the ridge plate u' , whose other end is nailed into the angle formed between the two valley rafters w' and v' .

The ridge plates z and u' and the header rafter t' must, of course, be perfectly true and level, and when set they must be so securely fastened that subsequent operations will not force them out of line. The jack-rafters r' and p' may now be set in pairs, one each side of the valley rafter w' . This is done in order that the thrust may be the same on each side of the rafter at the same time, for, if we laid all the jack-rafters on one side at the same time, it would cause the valley rafter to bulge and curve out of line and prevent the opposite rafters from fitting properly.

For this same reason great care must be exercised in setting the jack-rafters q' , as, in driving them close into their places, we are apt to cause the header rafter t' to bulge inwards, and out of line with the gable rafters s' above.

182. After all the rafters are in place, the boarding of the caves is laid, as shown at o' , and above this boarding

the shingle laths *d'* are laid, with a clear space between them equal to the exposed length of the shingles. The spacing of the shingle laths is measured from the lower edge of the lowest roof-board at the eaves, and the spaces are measured off up the rafters to the ridge, where any difference in exposure of shingles can be taken up by increasing, or slightly diminishing, the width of the ridge boards when they are laid. Side sheathing, roof sheathing, and shingle laths must be nailed to each stud, or rafter, with two nails for boards and one nail for shingle lath; where a joint occurs in a length of board, or shingle lath, it must be in the center of the rafter, or stud, and both joining ends must be securely nailed to the supporting timber.

183. The rough framing of the building may now be considered as complete. The skeleton is up and covered in with its sheathing; the floorbeams, or joists, are in position, and the rough, diagonal flooring is laid; the partitions dividing the interior are all studded, and the openings for doors and windows have all been framed and sawed out through the sheathing.

It now remains for the carpenter to lath the partitions, cross-fur and lath the ceilings, nail on the grounds which are to secure the wainscot, trim, picture moldings, etc., on the inside of the building, and to set the frames for the windows and doors, apply the outside casings, put on the clapboards, or siding, and shingle the roof on the exterior of the building; his work will then be practically complete, until after the joiner and painter have finished. In many localities, lathing is executed either by special lathers or by plasterers.

184. Before the walls are lathed, it is sometimes desirable in buildings where the ceiling is high, to provide a line of bridging between the studs, as shown at *h'*; the bridging tends to make the walls stiffer sidewise, and the studs are thus prevented from warping.

At *f'* is shown a filling of *brick noggs*, as they are called, from the top of the foundation wall to the top of the beams

This nogging consists of pieces of old or broken bricks, laid in lime mortar so as to completely fill the spaces between the studs and up to the top of the beams, as shown at *a*, Fig. 74, thus closing not only a passageway for cold drafts from the cellar, but also against the rapid spread of flames in case of fire. The brick nogging may, with advantage, be continued up three courses higher than the beams, between the studs, which will prevent drafts at the floor level, caused by the circulation of the air through the channels between the stud-ding. Sometimes, where brick is not convenient, short pieces of 2" × 4" studs are filled in and spiked to the sill and beams.

VARIOUS DETAILS OF CONSTRUCTION.

PLASTER GROUNDS.

185. Plaster grounds, as explained in Art. 123, are simply nailing strips secured to the studs for receiving the trim; they consist of strips of wood from $\frac{5}{8}$ inch to 1 inch in thickness, according to the character of the plastering, and in width they vary from 2 inches to 3 inches, according to the purpose they are to serve.

In the angle formed at the meeting of the stud partitions and the rough floor, a strip 1 in. × 2 in. is nailed to the studs, and a similar strip is nailed about the height of the base-board above and parallel to it. To these strips the base is then nailed after the plastering is dry.

In dining rooms, kitchens, billiard rooms, etc., where a chair rail, or wainscot, is to be placed, another ground about 4 inches wide, is nailed to the studs 2 feet 6 inches to 3 feet above the floor, according to the height of the wainscot, and in parlors, libraries, reception rooms, etc., a strip 1 inch in width is nailed from 1 foot to 2 feet 6 inches below the ceiling to receive the picture molding. This latter strip is not generally used, as the picture molding may be placed directly on the surface of the plaster, wire nails being driven in the studs or furring strips, or into wood plugs in case of brick

partitions. Where a wood cornice is to be carried around a room, a ground must be provided for it in the angle between the ceiling and the side walls.

The surface of the stud partitions between these grounds are then lathed. The ceilings in ordinary work are lathed directly on the under side of the beams, but where a first-class job is desired, the beams should be cross-furred, as explained in Art. 126.

186. The interior of the house is now ready for the plasterers, but the carpenter should shingle the roof before the plasterer's work is started, in order to protect the walls and ceilings in case of rain. The shingling should be started as soon after the roof is covered in as is possible, and according to the methods previously explained.

SIDING.

187. Siding is the term which is applied to the material with which the exterior walls of a frame building are usually covered. There are two kinds, the *beveled* siding, and the *novelty*, or *patent*, siding. The former consists of sawed and planed boards in commercial lengths of about 16 feet and a width of from 4 to 6 inches. Its thickness is $\frac{5}{8}$ inch at one edge, beveling back to $\frac{3}{8}$ inch at the other edge, as shown at Fig. 73.

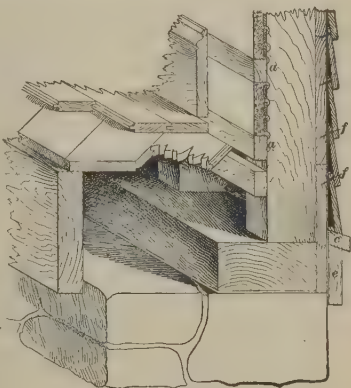


FIG. 73.

Novelty siding has a uniform thickness of about $\frac{7}{8}$ inch, except where it is rabbeted at the bottom to receive the chamfered edge of the next board below it, and where it is chamfered at the top to fit the rabbet of the board next above

it, as shown at *b*, Fig. 74. Novelty siding is manufactured in single widths of from 5 inches to 9 inches, though in very cheap grades of work it is used in double widths, with a groove worked lengthwise through the middle to imitate the joint, as shown at *c*, Fig. 74.

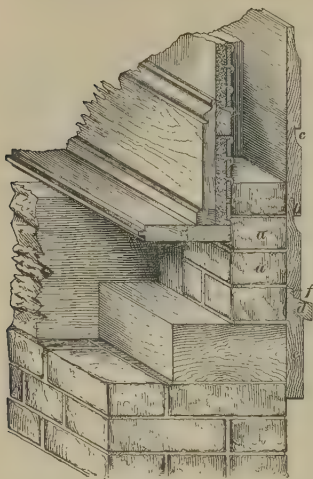


FIG. 74.

The depth of the rabbet and the width of the chamfer limit the amount of lap that can be made with novelty siding; whereas, with beveled siding, one course may overlap the other any distance within the limits of the width of the material. It is far preferable, therefore, to use the

beveled stock on all first-class work, though it costs a trifle more and requires more labor to put it in place. It is more durable on exposure to the weather, less liable to crack and check, while its thinness renders it easily dried out, and the stock is much more liable to be well seasoned than that used for the novelty siding.

188. Before the siding is put on the building, the **water-table** *e*, Fig. 73 and Fig. 74, is placed all around the structure about 1 inch below the sill. The water-table has a pitched cap, shown at *c* and *d*, which serves the purpose of receiving the water which runs down the side of the house and shedding it off to the ground before it works its way into the foundation, to rot the sill and render the house damp and unhealthy.

The cap of the water-table is beveled in order to give its top surface an inclination of from 15° to 30° from the horizontal, and it has a tongue worked on its top to form a seat for the lower piece of siding and make with it a water-tight joint, as shown at *f*, Fig. 74.

189. Over the sheathing of the building, from the water-table to the plate, is laid one or more thicknesses of heavy felt, or resinous building paper, to prevent drafts from working through the cracks and joints; and over this paper, and above the water-table, the siding is laid in horizontal courses, each course being nailed through its lower edge, as shown at *f*, in Fig. 73. Cut nails $2\frac{1}{2}$ inches long and having flat heads, should be used, the siding being nailed *only* at the studs and the nails set in, so that they may be puttied over. Beveled siding should be carefully gauged as to lap, so that the edges may be made to run in line with the horizontal lines of the window and door trim.

190. Circular Siding.—When a circular tower, or semicircular bay window, exists in a building, it is necessary to prepare the siding with its lower edge convex and its upper edge concave, in order that these edges may lie in horizontal lines when the siding is bent around the curved front of the tower. Fig. 75 shows the elevation (*a*) and the plan (*b*) of a portion of a circular tower, the siding of which must be worked with curved edges, as shown at (*c*). To find the radius and extent of this curvature the axial line *de* is drawn through the center of the tower and prolonged towards *e* indefinitely. The line *os* is then drawn as a continuation of the direction, of the inside slanting surface of one piece of the siding; *os* is prolonged until it intersects the axial line *de* at *x*, and with *x* this point of intersection as a center, and radii equal to *xo* and *xm*, respectively, the arcs *op* and *mn* are described. Then the

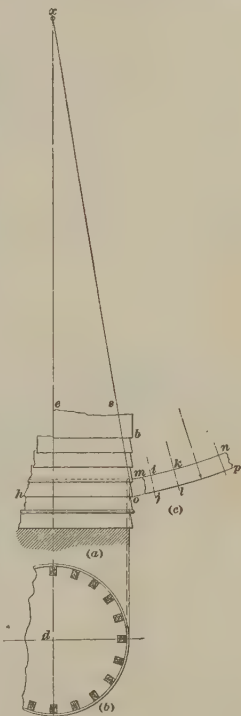


FIG. 75.

figure $mnp o$ will be of the form and curvature necessary to secure the level lines on the top and bottom of the siding after it is bent around the tower in the position shown at $o h$.

This form $mnp o$ should be first cut out of heavy paper, and then, using the paper as a pattern, the curve can be traced on each strip of siding and worked out with a draw-knife and plane. The exterior distance from center to center of the studs shown in the plan (b) should be marked off on the pattern piece with lines converging towards the point x , as shown at ij , kl , and all the butt joints between the ends of two pieces of curved siding should be cut on one of these lines, in order to insure a properly fitting joint and to have the ends meet in the center of a stud. When the siding is put on the building, its lower edge is laid and nailed to a line previously marked for it over each stud.

Where the siding is specially worked with a vertical back, so as to hug the sheathing, it can be applied in straight pieces; in this case, the surface of the tower is *cylindrical*, while in the other it is *conical*.

VERANDAS.

191. The details of the construction of the exterior features of a building require, on account of their exposed situations, especial consideration in order to insure the fulfilment of the purposes required of them.

Veranda construction must provide all the requirements of an out-door sitting room in fair weather, and at the same time insure the side of the house on which it is built against the invasion of water and dampness during a heavy rain storm, and effect the rapid drying of the floor and timbers after such a storm is over.

192. Fig. 76 is a perspective view of the details of veranda construction shown in drawing plate entitled, Constructive Details, *Architectural Drawing*. The floor d pitches at the rate of $\frac{1}{4}$ inch in a foot from the house line to the front edge at e in order to drain the water off as soon as it

falls. For the same reason the boards of the floor are laid across the veranda, as shown, as the water would otherwise lodge in the joints and soon rot out the material.

In order to run the floor boards in this direction, it is necessary to provide means of framing the floorbeams length-wise of the structure. Therefore, under each veranda post is built a brick or stone pier *a*, on which is laid the 4" $\times$ 6" sill *f* extending full length of the veranda, and from this

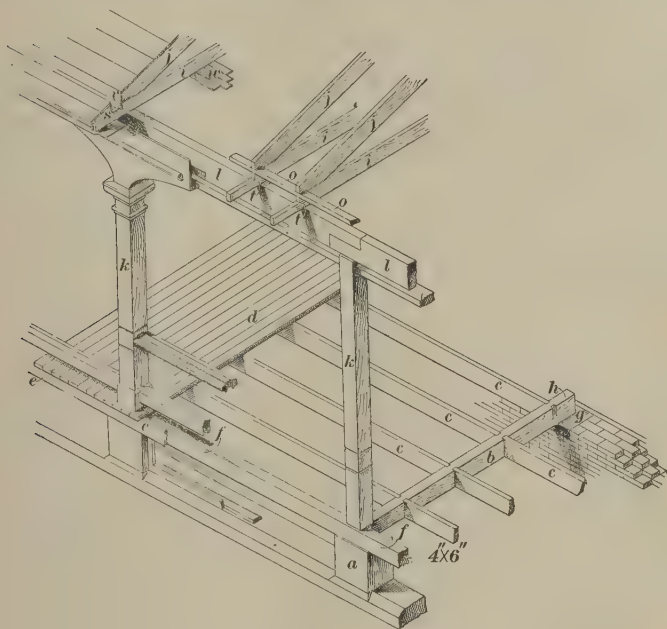


FIG. 76.

pier a girder *b* extends to the foundation wall of the house, where a stone templet *g* is built in to receive it; or, where the veranda is narrow, the girder simply rests on the brickwork without any templet. The veranda floor joists are then framed into the girder, as shown at *h*, and securely

spiked in place. In frame buildings the girders usually rest on a ledger board, well spiked to the sheathing.

In order to secure the necessary pitch of $\frac{1}{4}$ inch to a foot for the veranda floor, the girder *b* may be laid at the necessary inclination; or, its top may be planed, or sawed, down so that it has the proper pitch and the bottom remain level. In either case, the beams are framed so that their tops are flush with the top of the girder, and the flooring is laid directly upon them.

193. Veranda *flooring* should be at least $1\frac{1}{4}$ inches in thickness, tongued and grooved and laid in white lead; that is, the joint between two boards should be thoroughly filled with a pasty composition of white lead dissolved in raw linseed oil. This is accomplished by coating the edges of the boards with the mixture and driving them tightly together as they are laid. A good material for veranda floors is clear, dry white pine, heart stock, and free from all imperfections.

194. Veranda *posts*, whether square, as at *k*, or turned in a lathe, should be selected of good, sound, dry timber, which is the heart wood of the tree. After being sized to the required dimensions, they are carefully sawed squarely across the ends to an even length, the pores of the lower end of the wood are then filled with white lead, and the post is stood on the finished floor of the veranda. A girder *l* connects the upper ends of these posts and serves to support the ceiling beams and rafters *i* and *j*. On the ceiling beams *i* the plate *o* is spiked, and the foot of the rafters *j* is notched out to fit over it, as shown.

The inside ends of the beams and rafters are notched over a ledger board in the same manner as second-story floor-beams, where the building is of frame, and in brick or stone walls, they are built in and anchored, as described in Art. 108.

195. The roof, which pitches at the rate of 4 inches in a foot, will be boarded over with matched roofing boards and

then covered with tin, as the inclination is too flat for shingles or slate. The gutter is formed by cutting out about one-half the depth of the projecting portion of the ceiling beams, as shown at *l*, and sawing the lower end of the rafters to stand plumb over the girder *l*. The continuation of the roof pitch below the gutter is then maintained by spiking to each ceiling beam a triangular piece *s* and boarding it over to form the roof slope and gutter *z*.

The ceiling of the veranda may be formed with narrow strips of pine, or hardwood *zo*, laid on and blind nailed securely to each of the ceiling beams *l*. A better appearance is presented when the ceiling boards are placed at right angles with the building, in which case blocking or furring strips would be run at right angles with the ceiling beams. Sometimes the veranda roof is left open on the under side, exposing the timber construction. When this is the case, no ceiling beams are used, but the rafters are planed and dressed on their under sides, and the roofing boards are of selected, narrow stock, planed and matched, and laid with their finished sides downwards.

196. *Chamfering* is sometimes resorted to as a means of relieving exposed timbers of the sharp angle or corner where their finished faces meet. It consists of cutting off the corners of a girder, ceiling beam, veranda post, or other exposed timber, for a part of its length, and stopping the *chamfer* against an oblique cut made at an angle of about 45° , as shown at *a b* in Fig. 77, where *b c* is one of the chamfered corners of a square post.



FIG. 77.

197. Chamfered corners are very conspicuous in Swiss cottage architecture, where the entire framework of the building is more or less exposed and ornamented. The depth or breadth of a chamfered edge is entirely a matter of taste. Of course it should never be so deep as to impair the strength of the timber, while, on the other hand, it should be prominent enough to be clearly

seen from any point where the timber so treated is conspicuous. This is especially the case with girders and floorbeams, which, being above the eye, require a somewhat heavier chamfer than posts and railing, which are lower down and more closely observed.

CENTERS FOR ARCHES: DOMES.

198. Centers.—Where any portion of the outer or inner walls of a building are of brick or stone, and the openings in these walls are circular headed, the carpenter will be called upon to make wooden templets, or **centers**, as they are called, and set same in place for the mason to lay the stones or brick of his arch upon until the mortar has thoroughly set and rendered the arch self-sustaining.

199. In Fig. 78 is shown a wood center for a semicircular window in a 12-inch brick wall; (*a*) is the side view of the

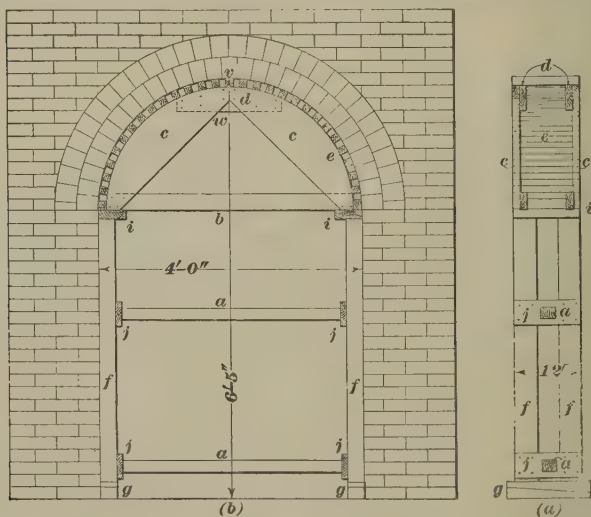


FIG. 78.

center and its supports, and (*b*) the elevation of the center in position in the wall. The faces of the center are, in this

case, each composed of two pieces *c* of $1\frac{1}{4}$ -inch plank sawed to the proper curve and secured at the bottom by the tie-piece *b*, which is securely nailed to each of the face pieces *c*, *c*, while the joint at the top is secured by the fish-plate *d* nailed to both pieces on the inside of the boards.

Two of these face pieces having been thus formed, they are joined together with small strips, called *lagging*, $1\frac{1}{4}$ inches thick, $1\frac{1}{2}$ to 2 inches wide, and 12 inches long, as shown at *e*. The bottom of the face pieces is secured by two *caps i* nailed to each face, under which the supports *f* are placed, when the center is set in the opening ready to be built upon. The lower ends of the supports *f* do not rest directly on the sill of the opening, but upon two slip wedges *g*, which are gradually driven out after the masonry has set, thus allowing the arch to gradually settle down to its own proper bearing. The braces *α, α* are inserted between the cleats *j* to maintain the supports in a vertical position against the jambs of the opening. All wood arch centers may be framed very nearly in this same manner, except in very large spans, where heavier timbers must be used.

200. Elliptical centers are formed in the same manner as those for circular arches, but usually require more pieces in the curved faces. For this reason it is advisable to lay out, on paper, a semiellipse of the required height and span according to the method described in problem 24, *Geometrical Drawing*, and with this paper form lay out the curved line on the several pieces of plank which have previously been arranged to occupy about their proper position in the finished center, as *a, b, c*, and *d*, Fig. 79. The curved edge is then sawed out on each piece separately, the ends are then sawed to the proper miter line, and fish-plates are nailed on the back in the same manner as *d* was nailed on *c*, in Fig. 78. When great strength is required, it is sometimes advisable to make these fish-plates as large as their face pieces *a, b, c, d*, and miter their ends to an even joint, as shown in Fig. 79. The ends are secured in place by the tie-pieces *f* and the caps *g*, while the center is strengthened by a strut *e* extending

from the tie-piece *f* to each of the intermediate sections of the face pieces, as *b* and *c*. The small $1\frac{1}{4} \times 2$ " strips are then nailed on the curved edges in the same manner as for

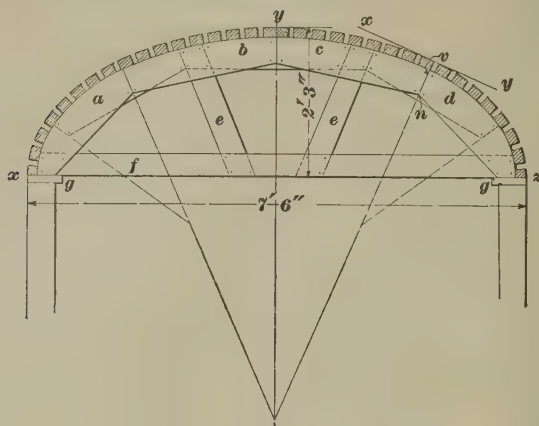


FIG. 79.

the semicircular center, their length being equal to the thickness of the wall in which the arch is to be built.

201. In all wood centers the joints between the different sections of the face pieces should always be in a line perpendicular to a tangent at the point where the joint line intersects the curved line of the arch; that is, in Fig. 79 the joint line *nv* is perpendicular to the line *xy*, which is tangent to the curve at *v*. These joint lines will all converge towards the center from which the curve is struck when the arch is semicircular, as *vw*, in Fig. 78, but in other curves they can be found only by first drawing the tangent, as in Fig. 79.

202. **Trimmer-arch centers** are built to extend from the brick wall of a chimney to the header beam of the floor, where it is framed around a fireplace, as shown in Fig. 80.

A characteristic difference between the trimmer-arch center and those previously described, is that the wood center is generally left in place and remains in the building after the masonry arch is laid over it. When the mason builds the brickwork of the chimney he corbels out one course of brick about $1\frac{1}{2}$ inches at the level of the under side of the floorbeams, as shown at *e*, and the carpenter builds his center to have one end rest on the brickwork at *e*, and the other end notched over a $1\frac{1}{2}'' \times 2\frac{1}{2}''$ or 3" cleat *d* nailed on the header beam *a*. The face piece of the center *c* is $1\frac{1}{4}$ inches in thickness, and its upper edge, on which the

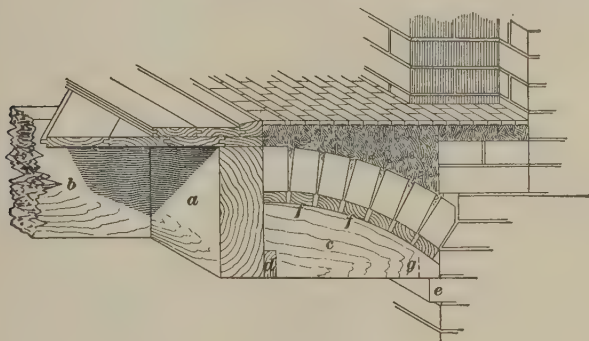


FIG. 80.

lagging *f* is nailed, is sawed to the curve of the arch so that the small end will be about $1\frac{1}{2}$ inches in thickness where it rests on the brickwork at *e*, and is about $4\frac{1}{2}$ or 5 inches less at the large end than the depth of the floorbeams. The number of pieces like *c* required for a trimmer-arch center depends on the length of the hearth which is to be built over it; but if the ceiling below is to be plastered, it is desirable to have one in front of the end of each tail-beam where it mortises into the header, in order to simplify the lathing.

Sometimes the lathing can be more readily accomplished by nailing a filler piece between the face pieces *c*, as shown by the dotted line at *g*, and then running the lath strips from

the filler *g* to the nailing cleat *d'*; but, unless the hearth is a very long one, the former method will be found most satisfactory.

203. When the roof of a building is carried up, either wholly or in part, in the form of a hemisphere, or semi-ellipsoid, it is called a **dome**, and the rafters supporting it must be sawed or bent to the required curvature.

204. A hemispherical dome is shown in Fig. 81, in which (*b*) is a half plan, and (*a*) is the sectional elevation.

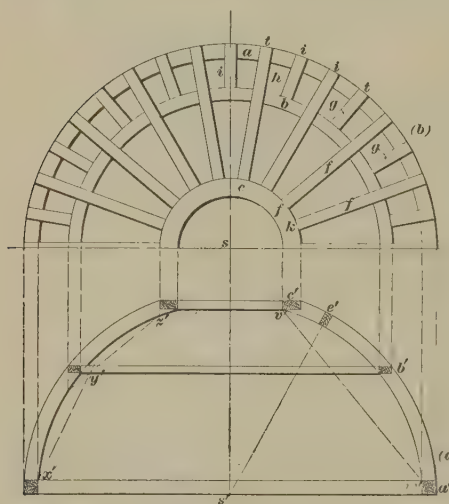


FIG. 81.

The curve of the dome is described from *s'* as a center with a radius *s' e'*. This is also the curve of the outside of the rafter. The center of the plan *s* is the point from which the curved outline of the plate *a* is described, on which the feet of the rafters *f* rest. At *c* is the upper plate, which receives the upper ends of the rafters *f*, and at

the same time forms a circular opening, called the **eye** of the dome, which admits light and ventilation. About half way up the curved outline, at *b'*, is shown a line of purlins cut in between the main rafters to receive the upper ends of the small jack-rafters *g*. This line of purlins is shown at *b* in the plan, and it is at about this point that the main rafters are spaced at a uniform distance of from 16 inches to 24 inches apart, the jack-rafters being then

inserted between their lower ends and spiked to the plate *a* and the purlins *b*.

The method of forming, or building up, the plate *a* is the same as described for the conical roof in Art. 144, and the rafters are bent, or sawed, in the same manner as the curved rafters of the oggee roof, described in Art. 148. Where bent rafters are used they are composed of thin strips bent over a form, each layer being nailed together. When the dome is for exterior effect only, and the inside is not to form part of any particular room, the rafters need not be sawed to a curved line on the under side, but may retain the straight edge of the board from which it is sawed, as shown by the dotted line *v'w'*, or, if composed of two pieces, by the lines *x'y'* and *y'z'*.

205. There are two methods of boarding over the curved surface of this dome. The first method is shown in Fig. 82, where *nof* is the outline of the curve of the plan of the dome, and *ab* is the outline of the curve of the elevation. From *c*, the center of the plan, we draw the line *cd* of indefinite length, but at right angles to *cb*, the axis of the elevation, and at *er* on the plan, we lay off the width of one of the roofing boards, *oe* and *or* being each equal to one-half the width of a board; the lines *ec* and *rc* then represent this board in place on the plan. The line *ab* is then divided into any number of equal parts, the points of division being marked *s*, *s'*, *s''*, etc., and these parts are then laid off on *cd* from *o* so that *od* represents the length of the line *ab* folded out straight, and *of*, *of'*, etc. are each equal to *as*, *as'*, etc. From *s*, *s'*, etc. we now draw perpendiculars through *co*, cutting *ce* and *cr* at *l*, *l'*, etc. From the points *f*, *f'*, etc., on the line *od*, draw lines at right angles thereto, and make *tf* equal to one-half of *ll*; *t'f'* equal to one-half of *l'l'*, etc. A curved line drawn through the points *t*, *t'*, etc., to *t^v*, will be the outline of the **gore**, or covering board required, and if this be laid out on a sheet of heavy paper and cut to the lines, it will form a templet, by which all the boards may be marked and cut. To support the

each part being equal to the width of one of the covering boards; the line bc is drawn from the point b through the point c and is prolonged until it intersects the axis of the dome prolonged at h ; then from the point c through d a line is drawn until it intersects the axis line at j , and so with each of the other parts, until we get the points k, l, m , etc., on the axis line. With h as a center and a radius hb , we can now describe the curve which will form the lower edge of the board bc , while with the same center and a radius hc we describe the arc cp , which marks the curvature of the upper edge of the board. From the point j as a center, and with the radii jc and jd , we describe the arcs ct and du , which mark the outline of the board cd , and in the same manner for each of the boards in the dome, until the top opening, or eye, is reached, which, when not to be framed, is closed over with a flat, circular piece of board, the center of whose curvature would be at e .

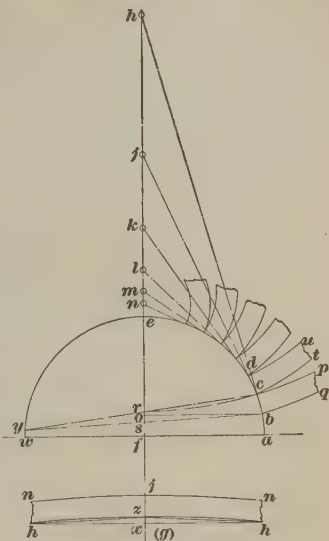


FIG. 83.

207. When a dome is comparatively small, and great neatness is required in the perfection of its semicircular outline, it is desirable that the joints should be planed down to round the surface, whether the boards run horizontally around the dome, as in Fig. 83, or extend from bottom to top, as in Fig. 82.

When a dome is large and well above the eye, as on the roof of a high building, such nicety is not required, as the covering material will round the form to the desired outline.

208. An interior dome is sometimes built under a flat roof, and is very commonly seen over a stair hall, which is illuminated through an ornamental glass skylight inserted in the eye of the dome. These interior domes are generally elliptical in form, but whether the outline is a semi-circle or semiellipse, the method of framing is precisely the same.

Fig. 84 is the plan of an interior dome whose outline is an ellipse, with a length $a c$ and a width $b d$. In its center is shown the eye, whose length $k g$ and whose width $e f$ are in

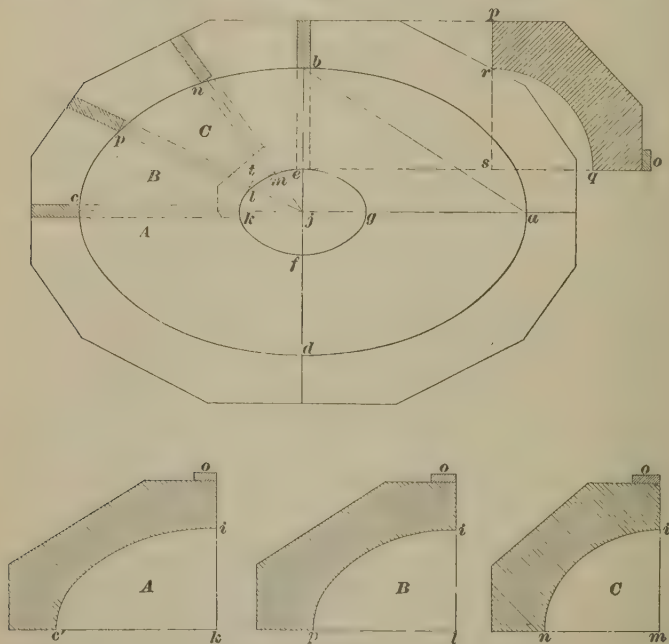


FIG. 84.

direct proportion to the length and breadth of the larger ellipse. The plan of the dome $a b c d$ is formed by cutting the curved sides from separate boards and nailing these boards around the opening framed in the floor or roof over

which the dome is to be built. The eye of the dome is made of four or more pieces of board securely nailed together to receive the upper ends of the ribs when set in place.

There will be four sets of these ribs, each set representing one-quarter of the dome. The rib bc will have for its curve a quarter circle with a radius eb , as shown at $opqr$, where the points e and b have been projected to q and r , and the arc rq has been struck from s as a center, with a radius sr equal to eb . The other ribs mn , lp , and kc have each the curve of a quarter ellipse, whose shorter semiaxis is, in each case, equal to the height of the rib bc , shown at sq , and their larger semiaxis will be the length of each rib in plan, as mn , lp , and kc . These ribs are shown at A , B , and C , the vertical heights ki , li , mi , each being equal to sq ; on each of them, is shown at o the section of the eyepiece t , which holds them in place. Such a dome as this should be lathed with wire lath, as it is impossible to preserve the curvature with wood lath.

209. A **groined ceiling** is formed by the intersection, or crossing, of two arched passageways; the framing required for it is shown in Fig. 85, where A is an arched passage 3 feet 8 inches in width, intersected by another arched passage B , 6 feet 4 inches in width. At bfd is shown the soffit of the arch over A , revolved on the exterior line of the thickness of its material to keep it clear of the other details, and at bgc is shown the soffit of the arch over B , revolved in a similar manner. The lines of intersection of these arched, or vaulted, surfaces are called **groins**, and they occur on the diagonals ab and cd , which intersect at o . If both passages were of the same width, both arches could be semicircular, as is the arch over A , but as B is much wider, and at the same time no higher, than A , the curve of the arch over B becomes a semiellipse, with its longitudinal axis bc equal to the width of the passage, and its semitransverse axis over the axial line of the passage B equal to the height fq of the semicircular arch over A ,

The groins ab and cd will also be semiellipses, and their curvature and the necessary dimensions for the ribs may be obtained by erecting on perpendicular to ab and equal in length to fq , and then describing the quarter ellipse $br'm'n$, with on as its semiminor axis, and ob as its semi-major axis. These ellipses may be described according to the method explained in *Geometrical Drawing*; or, points

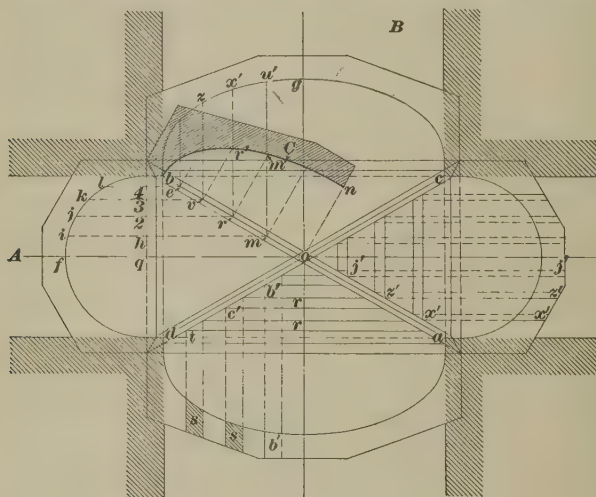


FIG. 85.

on the curves may be determined by projection. From any points on the circular arch, as i, j, k, l , draw the lines im, jr, kv, le , parallel to of , and where these lines intersect the diagonal line ob , erect perpendiculars both to the groin and to the measuring lines. Then, by laying off successively on these perpendiculars the distances $ih, j2, k3$, and $l4$, from m, r , etc. on the line ab , and from line m', r' , etc. on the line bc , points will be established through which may be drawn the ellipses bn and zg .

210. A pointed arch is one composed of arcs struck from two or more centers whose curves are not tangent to each

other, but meet at an angle, as shown at *f*, Fig. 86. The ceiling of two intersecting passages which are vaulted in the form of a pointed arch, or vault, forms a groined vault not unlike that just described.

Between these intersecting groin ribs, small jack-ribs or rafters *r* are framed, and their curved outline is precisely the same as that of the main ribs *bgc*, Fig. 85, as far as they reach each side of the center, or axial,

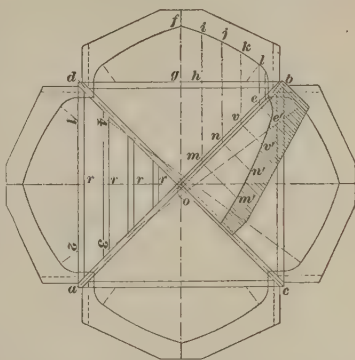


FIG. 86.

lines. The main ribs and jack-ribs are spaced from the center *o* at a uniform distance of 16 inches, or 24 inches on centers, according to the span, and lath is then applied in the usual manner to the under side.

The lengths and cheek-cuts of these jack-ribs may be determined by projecting their points of intersection with the groin ribs to the curve of the main ribs. Thus, from the points *j' z' x'* and *b' c' t* on the groin ribs *oa* and *od*, Fig. 85, draw the lines *j' j'*, *x' x'*, etc.; the exterior lines of each rib will determine the length of the side of the jack-rib which is farther away from the point *o*, and the interior lines for each rib will mark the length of the jack-rib nearer the point *o*; then, if these lines are marked on opposite sides of the jack-rib, a line connecting their ends across the edge of the jack-rib will mark the cheek-cut, as shown for the two longer jack-ribs at *s*.

211. The pointed vault shown in Fig. 86 is composed of the arcs of two circles described from four centers, 1, 2, 3, 4, as shown by the radial lines. The smaller arcs at the sides of the vault, described from centers 1 and 2, are tangent to the larger ones described from centers 3 and 4, but these two last named arcs are not tangent to each other, and,

therefore, form a point at the center which is over the axial line of the passage. The diagonal or groin ribs are laid out, as explained in Art. 209, by means of lines projected from points on one of the arches parallel to the axial line fo , and intersecting the groin line ab . Perpendicular to the groin at these points of intersection the lines mm' , nn' , vv' , and cc' , are drawn equal in length to ih , etc., respectively, and through the points m' , n' , v' , c' , the curve of the groin is described. The wooden rib, whose under side forms the contour of this groin, is shown by the shaded portion.

Between these intersecting groin ribs small jack-ribs r are framed, and their curved outline is precisely the same as that of the main ribs dfb as far as they reach on each side of the center line. The main ribs and jack-ribs are spaced from the center o at a uniform distance of 8, 16, or 24 inches, according to the span, and lath is then applied in the usual manner to the under side. The bevels for cutting the ends of the jack-ribs are found in the manner previously described.

212. Pendentives.—Another method of finishing the roof or ceiling over the intersection of two passageways, is

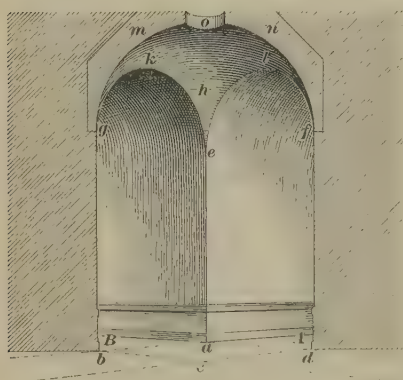


FIG. 87.

to construct over the crossing a hemispherical dome, when the passages are of the same width, and an elliptical dome when they are of different widths. The effect of this treatment is shown in Fig. 87, where the passage A intersects and crosses the passage B , and the sides of each one, prolonged by dotted

lines, forms the rectangle $abcd$, which is the plan of their

intersection. The roof of each passage is vaulted over with a semicircular arch, as gke and elf , while from the points e , f , and g , where these arches spring, there also starts a hemispherical dome $gmouf$. The corners e , f , and g gradually round over to the eye of the dome at o , and at the same time broaden out in a fan shape over each of the adjacent arches, as seen at ekl .

This spherical triangle ekl , which brings the curvature of the dome down to the corner of the passage at e , is called a **pendentive**, and there is, of course, one of them over each of the corners a , b , c , and d .

213. To develop the curvature of the ribs and construct the frame work for the dome and pendentives, the plan of the intersecting passages is first drawn, as shown in Fig. 88, at $abcd$; next, the axial lines of the passages AA and BB and the diagonal lines of their intersection, over which the ribs $v'a'$, gg' , ac , and bd are located, are drawn. Then with center o , and with a radius oa , draw a circle through the four corners of the plan $abcd$; this circle will represent the plan of the dome. If this dome is now cut on the line dc at right angles to its plan, the section produced will be the semicircle ced , which is the arch over passage A .

There will be four of these arch ribs, one over each of the lines ab , ad , cb , and cd , and that part of the dome which would extend into each of the passages, as at avd , is cut off by the arches over the entrances to the passages A and B . Now, as the dome is a hemisphere, any section of it through the center of its plan will be a semicircle, whose radius is the same as that of the circular plan, and we can consider the semicircle bcd as a revolved section through the dome on the diagonal rib bd ; $bciuy$ will then represent that rib as it would appear when cut out of its plank with its lower end b resting on the corner, and its upper end c standing over the center o , a distance of oc higher than the end b .

Four of these ribs will constitute the diagonals ac and bd , and the jack-ribs as og , oh , oi , etc. will have the same curve exactly as far as they reach, but their upper ends will

be beveled and pointed to fit in around o , while the lower

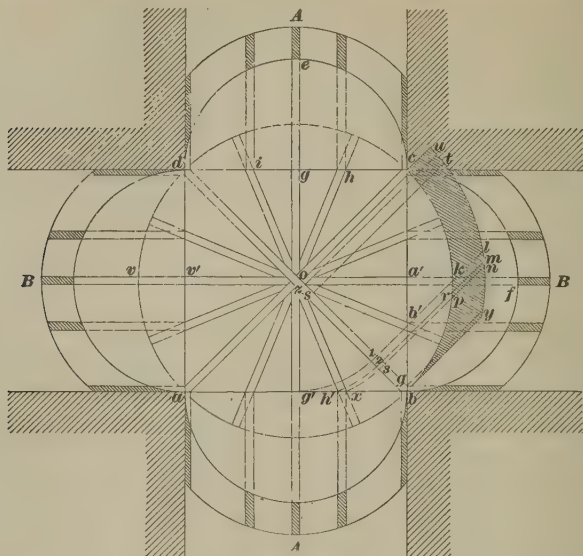


FIG. 88.

ends will require a plumb-cut and a cheek-cut to fit them against the arch pieces at ab , ad , cb , and cd .

214. To find the lengths and cuts for these jack-ribs, from the points z and s , where the sides of the ribs oa' and ob' intersect the side of the diagonal ob , draw zu and st parallel to oc . The line zu , where it crosses the rib bcy , will mark the shoulder from which to bevel the end of the rib oa' , and the line st will mark the shoulder from which to bevel the rib ob' ; the end piece uc will be cut off, as the rib ob' does not reach to the center o .

Now with o as a center, and with the radii og' , oh' , and ox , describe the arcs $g'1$, $h'2$, and $x3$, which will measure the lengths of each side of these jack-ribs on the diagonal rib ob ; and the lines $1l$, $2m$, and $3n$ perpendicular to ob will cut the rib bcy to the required lengths for the jack-rafters; $culk$ will be the pattern for four of the jack-ribs

og' , oa' , og , and ov' , the cheek-cuts being determined as explained above, and $cunp$ will be the pattern for the other jack-ribs, whose plumb-cut, where they join the arch ribs ced , cfb , etc. will be the line pn on one side of the rib, and the line rm on the other side, while a line drawn on the top or bottom of the rib joining the ends of the plumb-cut lines will mark the cheek-cut or bevel.

215. In lathing the ribs of the passages, ordinary wood lath may be used, but the pendentives and dome must have metallic lath so that they may be smoothly finished in plaster.

216. Niches.—Vaulted, groined, and domed passages, such as those just described, seldom occur except in monumental work, and the side walls of such passages are often broken by niches for the reception of pieces of statuary, vases, etc. Fig. 89 shows the construction of such a niche. The plan (a) shows the base acb , composed of $1\frac{1}{4}$ -inch plank; halved into the front edge of this base are the two studs a and b , shown in the elevation (b) at a' and b' , extending from the base to the head piece k , to which they are nailed. The studs n , o , p , etc., extend from the base to the plate l , on which rests the curved ribs n' , o' , p' , giving the head of the niche a semi-domical form; the front is closed by two quarter-circle ribs efg , let in and nailed to the studs a' and b' . Bridging, or stiffeners s , are inserted between the ribs, and the whole is then lathed with wire, or other metallic lath. The proportion of such a niche should be such that its height to e should be twice its width between a' and b' .

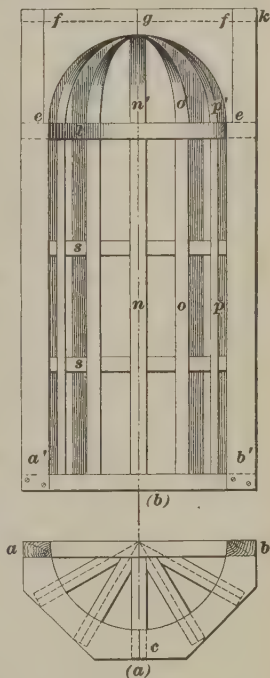


FIG. 89.

SLOW-BURNING CONSTRUCTION.

217. When a wooden building is constructed of good, sound, well seasoned material, and the workmanship on that material is first class in every respect, there is no reason why the house should not last 80 or 100 years, or even more, providing it does not burn down. In both braced-frame and balloon-frame buildings, the construction consists of a number of small pieces, such as studs, braces, floorbeams, etc., which burn rapidly and fiercely when a fire once gets started, and the spaces between the beams and studs form flues which give draft to the fire and spread it throughout the structure. If the building is not entirely destroyed the contents are usually ruined by smoke and water, and the beams and studs are burned and charred so that they are too weak to carry their loads, and have to be reinforced, or replaced. The immense quantity of water thrown into a building to extinguish the flames saturates all the material of which the building is composed, passes through the floors and partitions, runs down the staircases into the cellar, and soaks into the ground and foundation wall, often causing the house to settle in places and render a good job of repairing almost impossible.

In mills and factories where the floors carry heavy machinery, the fire eats the beams underneath, until the floor finally gives away and the machinery crashes through into the basement, causing the complete destruction of everything in its path.

In order to obviate many of these difficulties, **slow-burning construction** was introduced, and though at first used only in factories and mills, it is now frequently applied in every form of wooden building, including even residences and barns.

218. The fundamental principle of this form of construction lies in the omission or alteration of every detail of balloon or braced frame construction which would tend to make combustion rapid or easy. The individual members,

such as beams, columns, etc., are so proportioned that they retain strength enough to do the work required of them even after one-third of their bulk has been charred or burned. Instead of a large number of small pieces, as in balloon and braced frame construction, there is a small number of very large pieces in the slow-burning construction. Instead of $2" \times 9"$ or $3" \times 10"$ floor joists spaced from 12 to 24 inches on centers, we have $6" \times 10"$ to $12" \times 14"$ floor-beams spaced from 3 to 10 feet on centers. On top of these beams the rough floor is placed, but consists of from $3" \times 6"$ to $3" \times 9"$ planks grooved on both edges to receive $\frac{3}{4}" \times 1\frac{1}{2}"$ hardwood tongues, or **splines**, as they are called. The boards may be blind-nailed to each beam through the under lip of the groove. Before the spline is inserted the joints should be driven close and tight. Over this flooring is spread a layer of heavy felt, then cross-furring with $\frac{7}{8}$ -inch strips at 12-inch centers, the spaces between the strips being flushed with ordinary lime mortar. The finished floor is then laid with $1\frac{1}{2}$ -inch matched material. The furring strips may with advantage be run diagonally, thus reducing the effect of vibration caused by the machinery. The lime preserves the wood from decay; being a non-conductor, it retards the passage of heat between the floors, and at the same time it tends to make the floor waterproof, as it absorbs the oil which drops from the machinery.

The roof is covered with 2-inch plank and is rendered waterproof with tin, copper, tar and gravel, or painted canvas, though when the pitch is steep, slate and shingles are both used. When slate is the covering material, care must be given to see that the roof-boarding is extra thick and close-laid, as in case of fire, when the roof becomes heated and water is thrown upon it, the slates will crack and fall off. The inside walls of mills and factories are not plastered or finished in any way more than to make the construction clean and neat where it is fully exposed to view.

219. The ultimate objects of this form of construction may be summed up as follows: To make a building strong

enough to stand any ordinary stress, even after its timbers are partly burned; to make the floor so tight and strong that when a fire starts in one story, the water poured in to quench it will not run through and ruin goods on the floor below; to avoid any corners, pockets, or flues where fire could get started without being immediately discovered; and, above all, to provide a building where every part is easily accessible and the fire can be attacked and extinguished at close quarters without flooding the entire structure.

220. The details of this construction can be best understood by referring to Fig. 90, which is a perspective view of the flooring and supports of a portion of a mill erected according to the rules of "slow-burning construction."

In this example wood alone is used, though iron, brick, stone, and other refractory material often enter into the construction of buildings of this class. The posts *a* in the first story are 10" × 10" Georgia, or long-leaf, pine, and those in the second story *a'* are 9" × 9" of the same material. The girders *b* are of 12" × 14" Georgia pine, with a span of 15 feet from center to center of posts. Between the top of the posts and the bottom of the girders is placed a **bolster** *c*, which is 6 in. × 12 in. in section and 2 feet 3 inches in length. On top of this bolster the next column is placed, and on its projection, on each side of the column, rest the ends of the girders *b*, which may be secured in place by means of lag-screws.

Longitudinally through the center of each post *a*, and also through the bolster *c*, is bored a $1\frac{1}{2}$ -inch hole, and at *c* are shown $\frac{1}{2}$ -inch holes bored transversely through the ends of the column to give ventilation to the interior and prevent dry rot. Sometimes the under side of the bolster is counter-sunk, or rabbeted, about an inch deep in order to fit over the top of the post below, but a simpler method of securing it in place is by means of a piece of iron pipe inserted into the hole *d* as a dowel. **Drift pins**, or long spikes, may also be used for this purpose. After the columns and bolsters are set and the girders are in place upon them, the 4" × 6" cleats

f are bolted to the lower edge of the girders through the holes *g*, which have been previously bored to receive them.

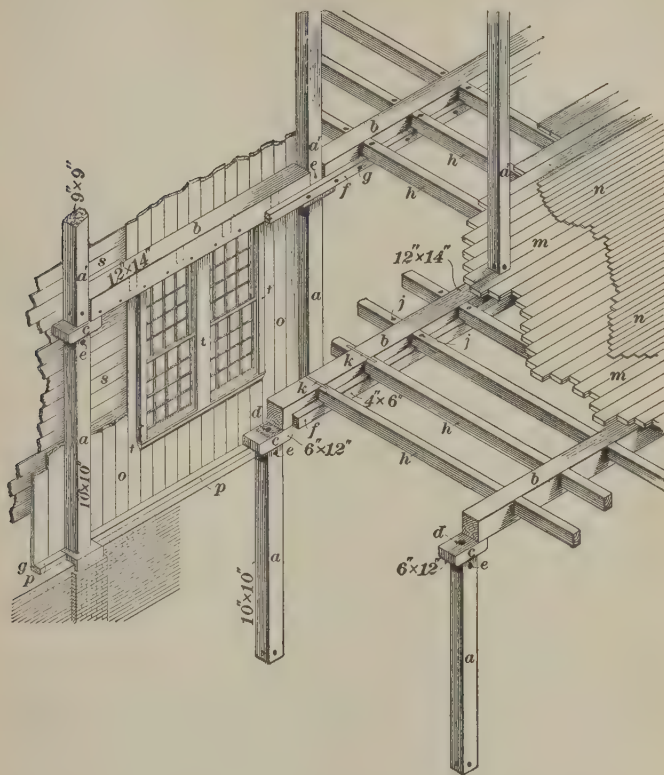


FIG. 90.

These cleats serve the double purpose of tying the girder system together longitudinally, and of forming a seat for the ends of the floorbeams *h*.

221. The floorbeams *h* are 6" x 9" Georgia pine, their lower sides being notched about 1 inch to bring their upper edges in line with the top of the girders *b* and are spaced 3 feet on centers. About 3 inches from each end of each

floorbeam a $\frac{3}{8}$ -inch hole is bored 2 inches deep, as shown at *j*, into which iron "dogs," shown at *k*, are driven; when the beams are in place, a dog made of a $\frac{3}{8}$ -inch round iron bar, 22 inches long, with 2 inches of each end bent at right angles, is driven tightly into the holes in the top of the floorbeams. This is shown more clearly in Fig. 91, where *a, a* are the $\frac{3}{8}$ -inch holes bored in the

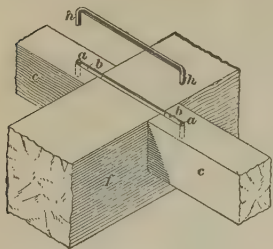


FIG. 91.

top of the floorbeams *c*. The purpose of the iron dog is to secure the ends of the floorbeams *h*, prevent them from slipping off the cleat *f*, and thereby form a continuous tie throughout the length of the building.

The floorbeams being in place and anchored, the under floor *m* is laid. This consists of 3-inch planks not more than 6 inches wide and planed on both sides, giving a finish to the ceiling in the story below. Two of these 3" $\times$ 6" planks are shown at *a, a*, Fig. 92, *b, b* being the grooves cut in both edges of each plank, and *c, c* the tongues of $1\frac{1}{2}$ " $\times$ $\frac{3}{4}$ " Georgia pine inserted in each groove as the board is laid. This renders the floor rigid, and the surfaces of the planks are kept flush.

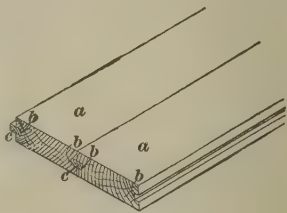


FIG. 92.

The finished floor *n* is then laid with 1" $\times$ 4" or $1\frac{1}{8}$ " $\times$ 4" maple, or hard pine, tongued and grooved and surfaced. The furring strips and felt lining above referred to are omitted in the cut to avoid confusion of lines.

Instead of the mortar filling between the rough and finished floors, several layers of waterproof sheathing paper is sometimes substituted, and though it renders the floor quite as water-tight, it is not so impervious to heat as the mortar, and, consequently, will not retard the progress of fire as well.

222. The outside walls of the building are built in the same manner as the interior; that is, posts support the outside ends of girders, and girders support the outside ends of floorbeams. The rectangular space enclosed by two posts and two girders, or floorbeams, is then closed in with 2-inch tongued and grooved plank laid vertically, as shown at *o*, in Fig. 90. The sill *p* is laid on the brick foundation wall, and may be rabbeted at *g* to receive the ends of the two-inch plank *o*. The entire exterior of the building is then sheathed with ordinary 1" $\times$ 8" sheathing boards *s*, over which matched and beaded planks may be laid vertically to form the exterior finish, or patent or beveled siding may be laid in the same manner as in a balloon frame. When the latter course is pursued, the sheathing boards *s* are usually laid diagonally, in order to prevent irregular courses of the clapboards, due to the shrinkage of the sheathing.

The window frames, being thicker than the boarding of the walls, are allowed to project inside, and are finished with a casing, as shown at *t*. The enclosing walls, therefore, act only as a protecting screen to the building, as the floor system is carried entirely by the posts and girders, and although these walls are but 4 inches in thickness, they are warmer and better in every way than the 7-inch stud and plaster partitions of the balloon frame.

223. Interior partitions are constructed of 2-inch tongued-and-grooved plank laid vertically from floor to ceiling, each plank being toe-nailed to the floor and ceiling cleats and driven well up against its neighbor. Where a neat finish is required on the partitions, as would be the case in enclosing a private office, the 2-inch plank may be lined with $\frac{7}{8}$ " $\times$ 3" matched boards of oak, or hard pine, laid horizontally or diagonally, or it may be plastered as explained further on in the application of this form of construction to residence work.

224. Roofing.—The roof of such a building as that shown in Fig. 90 should be as nearly flat as is consistent with a proper watershed, and built of 2-inch plank laid on roof

beams corresponding in position and spacing with floorbeams below. The roof beams need not be the same size and strength as the floorbeams, but should, under any circumstances, be of such proportions of breadth to depth as will insure their slow combustion should a fire get any headway beneath them.

225. This description of the essential features of mill construction applies to such buildings as are built entirely of wood, no important member being of iron or steel, and nothing save the foundation being of brick or stone.

Modifications of the details are, therefore, necessary, where the walls are of brick or stone; where the columns are of steel or cast iron; or, where the girders are composed of rolled-iron or steel beams.

226. Wooden beams, or girders, resting one or both ends on a brick wall, should have an air space all around the top sides and end of the beam to give ventilation and prevent dry rot. This may be done by keeping the brickwork $\frac{1}{2}$ inch away from the sides of the beam when it is built in the wall, but is much more satisfactorily accomplished by use of the Goetz-Mitchell anchor, shown in Fig. 93. This consists of an iron

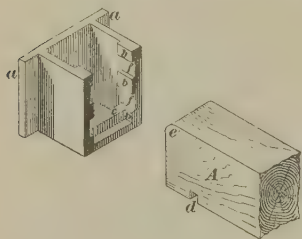


FIG. 93.

box, cast to fit the end of the beam, and possessing two projecting flanges *a*, which are enclosed in the brickwork of the wall, rendering the anchor a fixture. The box is cast about $1\frac{1}{2}$ inches wider inside than the wooden beam is broad, and about $\frac{1}{2}$ inch higher than the beam is deep.

Along the front edge of the casting are square cheeks *b* projecting about $\frac{3}{4}$ inch from the general surface of the interior. When the end of the wooden beam *A* is inserted in this anchor it is notched on its under side to fit over a raised fillet *c*, and the spaces *f* between the cheeks *b* give ventilation all around the beam inside the box-like casting. The

fillet *c* is generally 1 in. $\times$ 1 in., and the notch *d* in the beam, fitting tightly over it, prevents the timber from pulling out of the wall. The top of the beam is rounded off at *e*, so that should the beam become burned through at its center, it can fall down and out of the wall without disturbing any of the brickwork and thereby endangering the stability of the wall. The advantage of this is illustrated in Fig. 94, where (*a*)

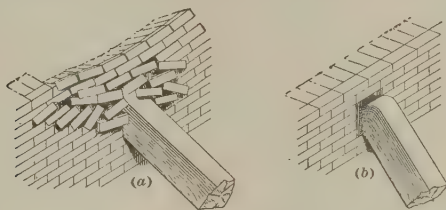


FIG. 94.

shows the destructive effect of a beam falling from a wall to which it has been anchored with the ordinary strap anchor, shown at *k* in Fig. 32, while at (*b*) the beam is seated in the cast-iron anchor above described, from which it can fall without damaging the wall in any way, and leaves the anchor intact to receive a new beam when repairs are made.

227. When this Goetz-Mitchell anchor is used in the masonry of a building, it is customary to replace the hard-wood bolster shown at *c*, in Fig.

90, with the cast-iron post cap shown in Fig. 95. This cap is cast with a socket 4 inches or 5 inches deep on its under side to fit the top of the wood posts, while flanges, shown at *d*, are left on its upper side to embrace the ends of the girders resting upon it.

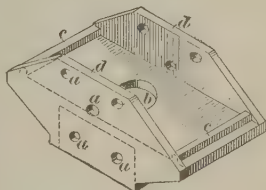


FIG. 95.

Holes are cored through the metal at *a* to ventilate the top of the post and ends of the girders, and thereby lessen the danger of dry rot, while a large hole *b* in the seat of the cap permits the insertion of a dowel in the top of the column

below, to which a superimposed post may be fitted. When used with this cap the girders are notched over the fillet *c* in the same manner as shown in Fig. 93, and a space of about $\frac{1}{2}$ inch is left between the ends of the girders and the sides of the post which is set between the upper flanges.

These anchors and caps are protected by United States patents, but may be cast in any foundry on the payment of one-eighth of a cent per pound to the Goetz-Mitchell Company, of New Albany, Indiana.

228. Cast-iron columns are frequently used in this class of construction on account of the ease of securing rigid

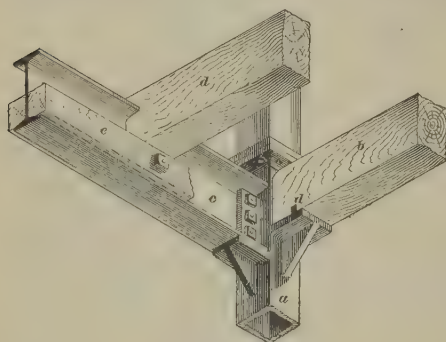


FIG. 96.

connections between the columns and beams, and also between the columns themselves in different tiers. Brackets are left on such columns to which the carpenter is to seat and anchor the ends of his beams and girders; when these brackets are

cast with a fillet, as shown at *d*, Fig. 96, the carpenter simply notches the under side of his beam, as for the caps and anchors above described. If a rolled-iron or steel **I** beam is used instead of a heavy wood girder, the carpenter will be called upon to sheath the beam in wood to protect it, and unless iron brackets are provided to seat the floorbeams on, he will also be required to provide a wooden ledge, as shown at *e*, Fig. 96, on which the beams are set and secured.

229. The methods of sheathing iron girders with wood and of securing floorbeams to them are numerous, and depend entirely on the purpose of the building and the economy of its construction. Under most circumstances, an exposed iron beam, such as is shown at *c*, will not stand the

heat of a fierce fire as long as a wooden girder of equal strength, such as is shown at *b*, in Fig. 90. The iron beam absorbs the heat and soon becomes so hot as to bend in the middle, thereby throwing walls and columns out of plumb, and finally causing a collapse of that entire part of the building in which it is located.

A wood girder does *not* absorb the heat, and when exposed to flames takes fire very slowly, commencing with the lower corners, or edges, and gradually burning up towards the center until it breaks through and precipitates its superimposed load to the floor, or cellar beneath.

If its ends are supported on a cap, such as shown in Fig. 95, or upon a bracket, as at *d*, in Fig. 96, it will probably release itself as it falls, and in no way endanger the floor above, as the burning material has been carried down with the girder and is farther away from the next tier above than before the floor fell. When, therefore, iron or steel beams are used in a building with wooden floorbeams they should be protected by wood; and the best method of accomplishing this protection is shown in Fig. 97, where *a* is a 15-inch I beam supporting, not only the floorbeams *b*, but also the partition *c*. Each side of the beam is filled and enclosed by two pieces of timber *g* and *g'*, which are worked to fit their positions from 4" × 8" stock and are held in place by $\frac{3}{4}$ -inch to $\frac{7}{8}$ -inch bolts *i* and *j*, spaced throughout the length of the beam *a* at about half the interval of the floorbeams *b*. The upper pieces of timber *g* are notched out where the floorbeams

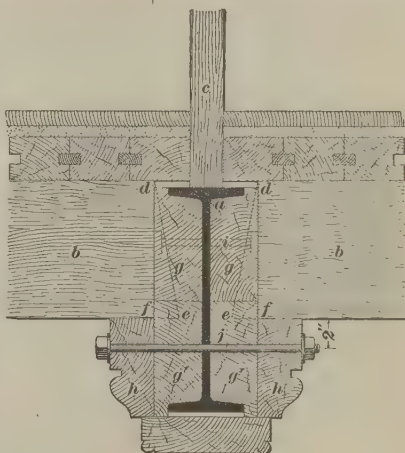


FIG. 97.

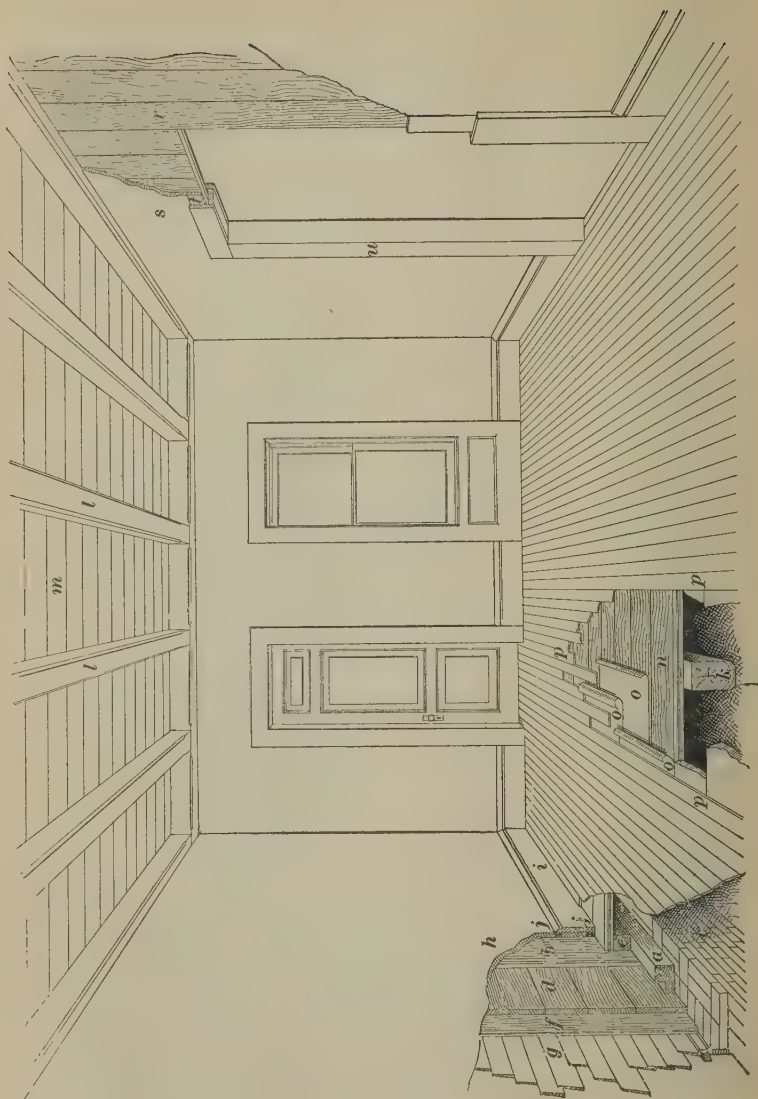


FIG. 98.

rest, as shown by the dotted line *def*. The end of the floor-beam is cut to fit this notch and seats itself on the lower timber *g'*, at *ef*. The bolt *j* passes not only through the two timbers *g'*, but also through the wooden ledges *h*, which are provided to give additional support to the floorbeams *b*.

Another piece of timber worked from 3"×8" stock, is secured to the bottom of the girder, thereby enclosing the entire iron beam.

230. Where a partition is to be supported by such a girder, the 2-inch or 3-inch plank forming the body of the partition stands directly on the iron beam, as shown at *c*, Fig. 97, and the 3-inch splined plank of the under floor is laid up to it on each side.

The mortar filling is then spread on the rough floor, and if the side wall, or partition, is to be plastered, the mortar is then carried up the side wall, on wire lath, before the finished floor is laid. The finished flooring is then laid on the nailing strips between the mortar filling and securely nailed through to the 3-inch plank. If a base is to be carried around the room, grounds are set for it, against which the plaster stops, as in ordinary balloon or braced-frame construction.

231. Private Residences.—It is only very recently that slow-burning construction has been applied to the building of frame dwellings, but it has been found to lend itself so readily to this purpose that the number of "mill-built" houses is increasing every day. Over and above the advantages of decreased fire risk, this system of construction gives the householder a residence warmer in winter and cooler in summer than can be attained by the ordinary balloon or braced frame, while it secures to him walls and floors through which it is absolutely impossible for mice and other vermin to run and breed; and it provides a house the endurance and lasting qualities of which are beyond anything to be secured in any other way, where wood is the material used.

232. Fig. 98 shows the interior of a room in a house built upon the system of slow-burning construction, portions of the floor and partitions being removed to show the

relation of the parts. At *a* is shown the sill 6 in. $\times$ 10 in. laid in lime mortar on the foundation wall *c*, while its outside edge has a rabbet cut in it 2 inches deep, to receive the ends of the 2-inch plank *b*, which take the place of studding in other framing. The sheathing *d* is ordinary 1" $\times$ 9" plank laid horizontally and thoroughly spiked to the 2-inch boards, while another layer of 1-inch sheathing is applied vertically outside of this, as shown at *f*. The object of this is to provide a surface to nail the siding *g* to, which will not throw the clapboards out of even alinement by its unequal shrinkage. If the siding were nailed directly to the sheathing *d* there would be danger of the clapboards separating in pairs as the boards *d* shrank in drying out. These three thicknesses *b*, *d*, and *f* also make the side of the house much stiffer and stronger than would the two layers *b* and *d*.

Sometimes, for economy of labor, the boards *b* are made 3 inches thick, and the boards *d* are laid over them diagonally; the siding is then applied to the diagonal boards.

The inside of the plank *b* is covered with stiffened wire lath and plastered directly against the wood; the stiffening ribs forming sufficient space for the clinch of the plaster. Grounds *j* are carried around the room before the plastering is done, and the base *i* is secured in place before the finished floor is laid.

The floorbeams, one of which is shown in section at *k*, are 6 in. $\times$ 9 in., spaced about 3 feet on centers. They should be planed and finished with sandpaper, the corners neatly chamfered, the surface receiving a coat of shellac varnish before they are set in place (provided that they are thoroughly seasoned), as they will form an open-timber ceiling in the room below, as shown at *l*. For the same reason the 2-inch plank *n* which forms the under flooring should be from selected stock, free from sap, shakes, or loose knots, and its under side should be planed and sandpapered before it is laid, as it forms the ceiling in the floor below, as shown at *m*. Over the underflooring *n* is laid one or two thicknesses of heavy felt *o* or a 1-inch layer of mortar, as previously described. The finished floor *p* is then laid in narrow strips, blind-nailed to the nailing strips and closely driven.

Inside partitions are formed of 2-inch plank set vertically, as shown at *r*, and plastered on both sides on wire lath, as shown at *s*. Around all door and window openings is carried a ground *t* against which the plaster stops, and to which the trim *u* is nailed.

233. The whole structure is thus rendered solid, substantial, and unyielding to any ordinary strain, while the absence of any small timbers reduces the fire risk to a minimum.

The first cost of this style of construction is greater than balloon frame or braced frame, but the saving in insurance rates and the reduction in the quantity of coal required to heat the house in winter offsets the interest on the extra money invested.

It is imperative that the timbers be thoroughly seasoned before paint, varnish, or other impervious coatings be applied, otherwise the natural sap, being prevented from evaporating, will ferment and cause *dry rot*. In mill-built structures, it is, therefore, customary to allow the heavy timbers to dry out for two or three years before they are painted.

To insure first-class work in any system of wood construction, it is essential that the wood be thoroughly seasoned, be free from sap, shakes, loose knots, and the other imperfections described. When in position in the building, it must be kept not only dry, but due provision must be made that no portions are so tightly sealed that pure air cannot come in contact with them. Timber thus excluded from pure air, whether in a damp or dry position, will soon rot; so that where impervious layers of paper, felt, etc. are applied, they should be in contact with only one of the surfaces.

234. The following table gives the sizes of timber used in the systems of wood construction of buildings heretofore described. These sizes are not absolute, and vary according to circumstances, but may be taken as a good average where any doubt may exist:

	Balloon-Frame Building Not Over 1,500 Sq. Ft. Area.	Balloon-Frame Building Over 1,500 Sq. Ft. Area.	Braced-Frame Building Not Over 1,500 Sq. Ft. Area.	Braced-Frame Building Over 1,500 Sq. Ft. Area.	Slow-Burning Construction.
Corner posts.....	$\left\{ \begin{array}{l} 2'' \times 4'' \\ \text{and} \\ 4'' \times 6'' \end{array} \right\}$	$\left\{ \begin{array}{l} 2'' \times 6'' \\ \text{and} \\ 6'' \times 8'' \end{array} \right\}$	$\left\{ \begin{array}{l} 2'' \times 6'' \\ \text{and} \\ 4'' \times 8'' \end{array} \right\}$	$\left\{ \begin{array}{l} 2'' \times 6'' \\ \text{and} \\ 6'' \times 8'' \end{array} \right\}$	$10'' \times 10''$
Sill.....	$4'' \times 6''$	$4'' \times 8''$	$4'' \times 10''$	$4'' \times 10''$	$6'' \times 10''$
Plate.....	$4'' \times 6''$	$4'' \times 8''$	$6'' \times 8''$	$6'' \times 10''$	$6'' \times 10''$
Interties.....	$3'' \times 8''$	$4'' \times 10''$	$4'' \times 8''$	$6'' \times 8''$	$8'' \times 10''$
Ledger boards.....	$1'' \times 4''$	$1\frac{1}{2}'' \times 4''$	$4'' \times 6''$	$6'' \times 6''$	$2''$ or $3''$ plank
Double studs.....	$3'' \times 4''$	$4'' \times 6''$	$2'' \times 4''$	$4'' \times 6''$	$6'' \times 8''$
Single studs.....	$2'' \times 4''$	$2'' \times 6''$	$4'' \times 6''$	$6'' \times 6''$	$11''$ plank, 2 thicknesses
Braces.....	$2'' \times 4''$	$2'' \times 6''$	$1'' \times 9''$	$1'' \times 9''$	$3''$ to $4\frac{1}{2}''$ plank
Sheathing.....	$1'' \times 9''$	$1'' \times 9''$	$1'' \times 6''$	$1'' \times 6''$	$\frac{7}{8}''$ to $1\frac{1}{2}''$ plank
Rough floor.....	$1'' \times 6''$	$1'' \times 6''$	$\frac{7}{8}'' \times 4''$	$\frac{7}{8}'' \times 4''$	$4'' \times 6''$ to $10'' \times 12''$
Finished floor.....	$\frac{7}{8}'' \times 4''$	$\frac{7}{8}'' \times 4''$	$\left\{ \begin{array}{l} 3'' \times 8'' \\ \text{to} \\ 3'' \times 12'' \end{array} \right\}$	$\left\{ \begin{array}{l} 3'' \times 8'' \\ \text{to} \\ 3'' \times 12'' \end{array} \right\}$	
Floorbeams.....	$\left\{ \begin{array}{l} 2'' \times 8'' \\ \text{to} \\ 3'' \times 10'' \end{array} \right\}$	$\left\{ \begin{array}{l} 3'' \times 9'' \\ \text{to} \\ 3'' \times 12'' \end{array} \right\}$			

JOINERY.

PROVINCE OF JOINERY.

1. Joinery, as distinguished from **carpentry**, relates to that branch of the woodworking trades which deals with those internal and external fittings of a house that are put in place after the rough framework and flooring are finished, such as the *floors, skirtings, casings, wainscotings, doors, windows, paneled partitions, stairways*, etc.

In joiners' work, close-fitting joints, accurate workmanship, and smooth finished surfaces are the chief points in view, as contrasted with the work of the carpenter, whose main object is to provide a frame or skeleton which shall be strong enough to resist any stress to which the building may be subjected, and arranged to comply with the requirements of the finished joinery.

Hence, while the latter deals principally with heavy timbers in the rough, the former uses smaller pieces of finer and more carefully seasoned woods, and joins and fits them with the utmost accuracy. The joiner, therefore, must work with much more care and to a higher degree of finish than the carpenter. All the surfaces he leaves exposed must be smooth and clean, ready for the painter, varnisher, or polisher.

His time is spent between the duties of the workshop and

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the building. In the workshop, he prepares the framed and paneled work, door frames and casings, window frames and sash, all classes of molded work, the various parts required for stairways, general trim and interior fittings. In the building, he attaches the finished woodwork to the framed base, consisting of false jambs, furring strips, and grounds, all of which the joiner should verify as to correct leveling, plumbing, and alinement before he applies the materials. True, these should have been placed correctly by the carpenter, but the careful joiner will always make an examination of existing conditions, so that he may better meet them intelligently.

JOINTS.

2. To insure durable and flush connections between the parts joined together, due consideration must be given to the form and character of the joints, so that the strains to which they are subjected may be either resisted or compensated. The strains may be caused either by the behavior of the material itself or by extraneous force in the working portions, as doors, shutters, and window sash.

In *Carpentry*, a number of joints commonly used in house building are described in detail; and though many of these joints are identically the same in principle as those used in joinery, there is a vast difference in the degree of accuracy required in the workmanship. In joiners' work, the joints may be divided into two classes, namely, *loose* joints and *glued* joints; the former consists of two or more pieces maintained in place by the shape of the parts of union, such as the dovetail joint, Figs. 8, 9, and 10; in the latter, the pieces are secured by means of glue, as in the miter joint, Fig. 2, the halved corner, Fig. 3, etc.

3. *Loose joints* are seldom used in joinery, except in heavy machine frames, and in pieces of cabinetwork which are made in sections for convenience of handling, or in the exterior finish of a building where exposure to the weather

would render the glued joint unreliable; and, in any case, the loose joint is usually rendered additionally secure by means of screws, nails, or wooden pins.

4. Glued joints require some mechanical contrivance to maintain them in position while the glue is setting, which usually requires from 12 to 48 hours, according to the quality of the glue, the condition of the atmosphere, and the temperature of the room.

5. Considerable experience is required in order to use glue successfully. The wood must be well seasoned and thoroughly dry, and the joint must be well fitted. In gluing hardwoods, the surfaces to be glued should be roughened with a toothed comb, to make the glue hold better; the room must be at a proper temperature, and the material must be heated, so that the glue will flow quite freely. The glue must be spread evenly on the parts, which are then placed together as soon as possible, and maintained in place by means of hand screws, bench clamps, or wedged frames. All superfluous glue is then wiped off and the work left until the joint is thoroughly dry.

The most frequent causes of bad gluing are the use of an inferior quality of glue and the unequal spreading of it. A good practical way to test any brand of glue is to glue together a piece of pine and a piece of ash, clamp them up with a hand screw, and when they are dry insert a chisel in the joint and try to pry them apart. If the joint separates where it is glued, the adhesion is inferior, and the glue should not be used for good work. The wood should split or give way rather than the material securing the joint.

6. The simplest joint made use of in joinery is the **butt joint**, shown in Fig. 1. Here the two pieces joined are simply butted together, in a similar manner to the butt joint in carpentry, but the adjacent surfaces are much more accurately fitted, and are held in place by means of screws or dowels—the former when the pieces joined are broad and

thin, as in Fig. 1 (*a*), and the latter when the timbers are heavy and thick, or when they are joined together on the thinner edges, as at Fig. 1 (*b*).

This joint is insecure in itself, and usually requires glue to make it in any degree reliable; or it may be kept in place by the woodwork behind, against which it is erected, as

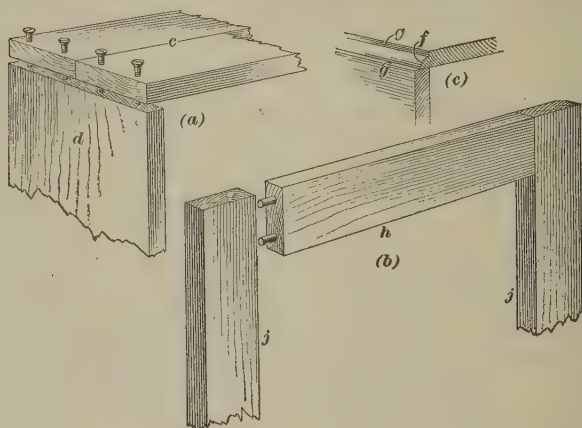


FIG. 1.

would be the case in an exterior casing for a window where the form shown at (*b*), Fig. 1, would be used, except that the top *h* would rest upon the sides *j*.

The plain butt joint, shown at Fig. 1 (*a*), is seldom used in first-class joiners' work, as the opening caused by shrinkage is very apparent. The absence of a device to keep the entire surface flush allows the fibers to curl, and the effect of shrinkage and warping would be to cause the pieces *c* in Fig. 1 (*a*) to project slightly over the side of *d* and render the juncture too apparent. This may be obviated to a certain extent when the grain runs parallel to the joint, by forming the joint as at (*c*); a quarter-round *f* is worked on one of the pieces to be joined, thus forming fillets, as shown at *g*. The joint, Fig. 1 (*a*), may also be doweled, as shown at Fig. 1 (*b*).

7. The **miter joint**, shown in Fig. 2, is generally used when the boards are of the same thickness, where no great strength is necessary, and where the conditions require that the angle shall show no end grain of the wood, either inside or outside of the joint. It is usually nailed or screwed together as

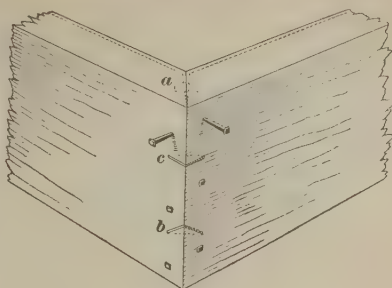


FIG. 2.

shown, but depends upon glue to make it secure, or is strengthened by a slipfeather or spline, as shown dotted at *a*. It is also sometimes secured by gluing in a key of thin wood, which is inserted in a saw kerf cut diagonally, as at *b*, or at right angles to the end, as at *c*. A keyed miter is most generally used for a joint seen only from the interior, as the keys disfigure the exterior appearance. This joint is also made with the broad portion of the wood on the face, as in the case of architraves and casings.

In mitered joints, the shrinkage of the wood does not change the appearance of the exterior of the joint, but causes the interior to open slightly, as indicated by the dotted lines. To obviate warping, however, a tongue is very essential.

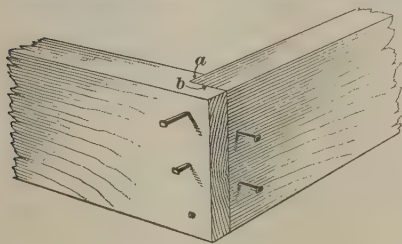


FIG. 3.

8. The **shouldered corner**, shown in Fig. 3, is a joint used where the inside angle will alone be visible, and is an improvement on the

butt joint shown in Fig. 1 (*a*), inasmuch as it provides two nailing surfaces, one at *a* and one at *b*.

9. The **shouldered-and-mitered joint**, shown in Fig. 4, is a combination of the forms shown in Figs. 2 and 3. It

presents the advantages of showing no end grain as does

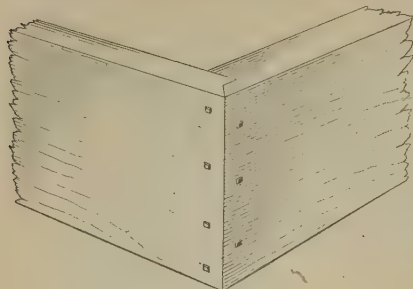


FIG. 4.

Fig. 3, and possesses the additional strength secured in the method of joining the pieces of Fig. 3. Its use, however, is limited to light work, where no great strength is required, and is principally serviceable where a miter joint is required be-

tween pieces of unequal thickness, as in Fig. 4.

10. The **tongued-and-grooved** joint, Fig. 5, the **dado** joint, Fig. 6, and the **housed** joint, Fig. 7, are all modifications of the same form, where the end of one piece

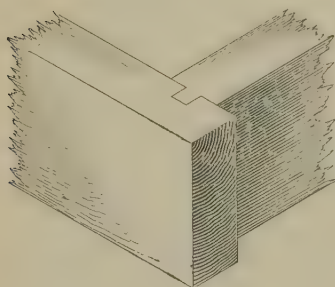


FIG. 5.

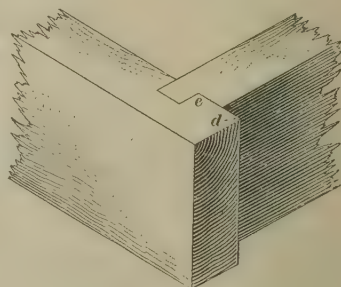


FIG. 6.

is let into the side of another piece about one-third of its entire thickness. These joints are very frequently used in joinery. They are secured by means of glue, nails, or screws, or may be left loose to allow the members to come and go in shrinking and swelling.

In joining the back and sides of a drawer, the forms shown in Figs. 6 and 7 are very frequently used, as the projection of the sides of the drawer, as from *c* to *d*, renders the end less likely to be pulled off by the jar of the contents when

the drawer is suddenly opened; and any unequal shrinkage of the two pieces will not tend to split the material, if the joint is not secured by too many nails.

11. The dovetail joint is one of the most important in joinery. It furnishes a rigid method of securing pieces together where the fibers of the material are approximately at right angles with the joint.

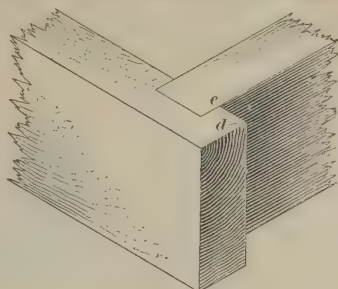


FIG. 7.

Upon analyzing the conditions of strength existing in a dovetail joint, it is evident that the strength of the entire joint depends upon the combined value of the dovetails, the same as a nailed joint depends upon the combined resistance of the nails, or as a nut on a bolt depends upon the aggregate strength of the threads for its holding power.

The extent to which this is true may be realized by considering wherein lies the strength of each dovetail.

In Fig. 8, the projections upon the piece *b* are liable to fail by the shearing of the flare or dovetail upon each side of the projection, the strength in this case depending upon the capabilities of the wood to resist shear across the grain; while the projections upon the piece *d* depend for their strength upon the resistance of the flares or dovetails to the shear of the wood parallel to the grain.

The projections upon the pieces *d* and *b* are also liable to fail by shearing through, or by breaking off where they join the main pieces of wood; consequently, the distance from *h* to *h* and corresponding distance on the projections on the piece *b* should never be so slight as to be liable to break before the shearing strength of the wood across, or parallel with, the grain is realized.

There is still another factor entering into the strength of a dovetail joint, and that is the adhesive strength of the glue which binds the fibers of the projections upon the pieces

united, giving rigidity to the joint and preventing the piece *d* from pulling away from *b* in a direction parallel to the grain of the latter.

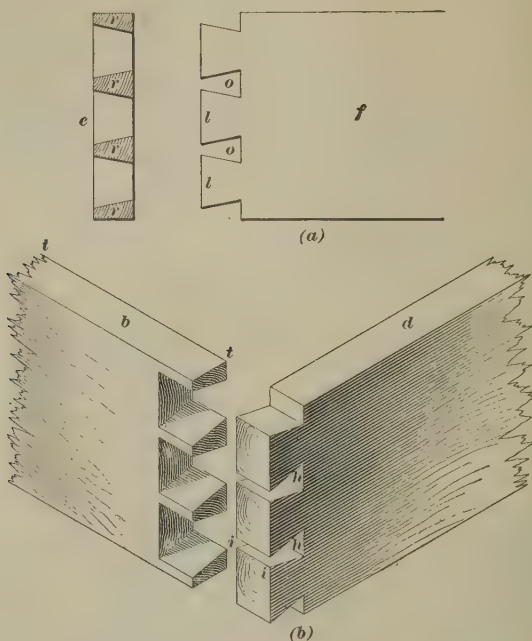


FIG. 8.

12. Dovetail joints are of three kinds. The common form, shown in Fig. 8, known as **lap dovetail**, has its dovetails on *d*, and its dovetail pins projecting from the body of the piece *b* a distance equal to the thickness of the piece *d*. The ends of the pins and dovetails show on opposite sides of the corner when the pieces are joined.

13. Another form, known as the **half-lap dovetail**, shown in Fig. 9, is a joint in which the pins *c*, though cut down from the end of the board *e* a distance equal to the thickness of the board *h*, are not cut entirely through the board *e*, but have, as at *f, g*, a lap which, when the joint is closed, covers the end of the dovetails on *h*, and prevents

the character of the joint from appearing on *e* at all, though the end grain of the pins *c* will show through the board *h*. This joint is well adapted for the fronts of drawers, as shown at (*a*), as the piece *e*, which shows no dovetails, forms the

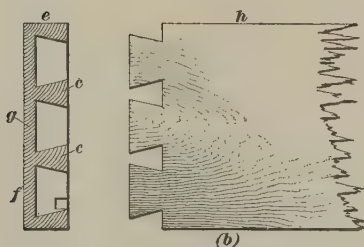
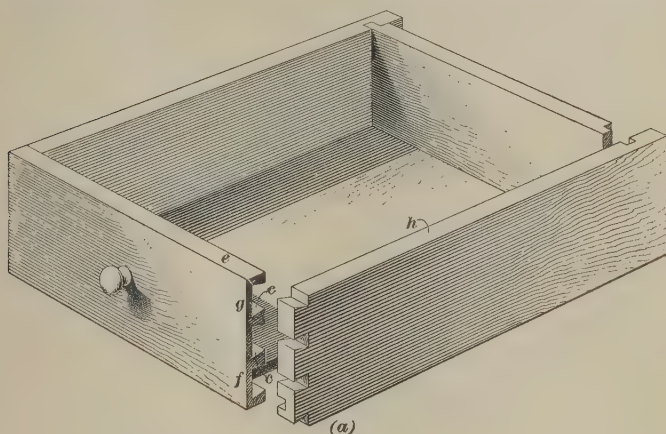


FIG. 9.

front of the drawer, and the ends of the dovetail pins, on the side piece *h*, are hidden when the drawer is closed. The side elevation of the joint, and the relative size of the dovetails and dovetail pins, are shown at (*b*). The reference letters refer to the same details in both (*a*) and (*b*).

14. The third form is known as the **blind or secret dovetail**, and is shown in Fig. 10. In this joint about

three-fourths of the thickness of the board is dovetailed, the remaining portion being united in a miter joint. Both the dovetails and the dovetail pins are here cut only partially through the board, and the upper pin *a'* of the piece *c* is cut off on the miter line of the angle, while the upper half mortise *b'* is cut only to the miter line of the piece *d*, thereby concealing entirely the details of the true character of the joint, when the pieces are united.

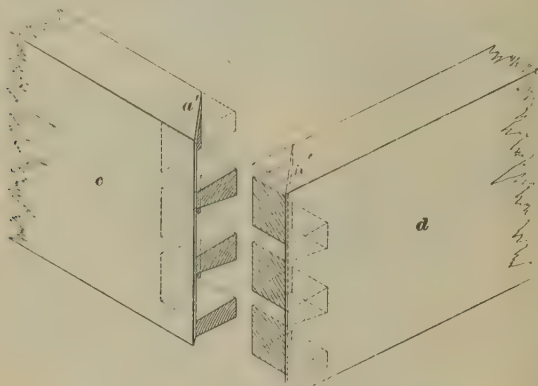


FIG. 10.

This joint is seldom used in joinery, except for the front corners of highly finished drawers and boxes, where, for the sake of appearance, it is better for the dovetails not to show. The blind dovetail is not as strong as either of the other forms, partly because it utilizes only a portion of the available thickness of the wood, and partly because, on account of their concealment, it is impossible to see whether the pins and mortises fit each other accurately.

In preparing the dovetail joint, the pins *r*, Fig. 8 (*a*), are marked and cut first; the piece *c* is then laid across the end *f*, and the mortises *e* are carefully scribed with a knife-point on the side of the end of *f*. The pins must be sawed square from the end, or parallel to the edge *ll* in Fig. 8 (*b*), and the mortises must be cut square across the end of *d* as at *ii*, the greatest neatness and accuracy being required to insure good work.

15. In all joiners' work, face and edge marks are made so as to distinguish the face and edge from which all measurements must be taken and all squaring done. At the same time they serve to assist the joiner in determining the edges that are to be in contact, and prevent mistakes due to putting the pieces together in other than their proper relations.

16. The **doweled joint**, shown in Fig. 11, consists of a plain butt joint between the two pieces *e* and *f*, either

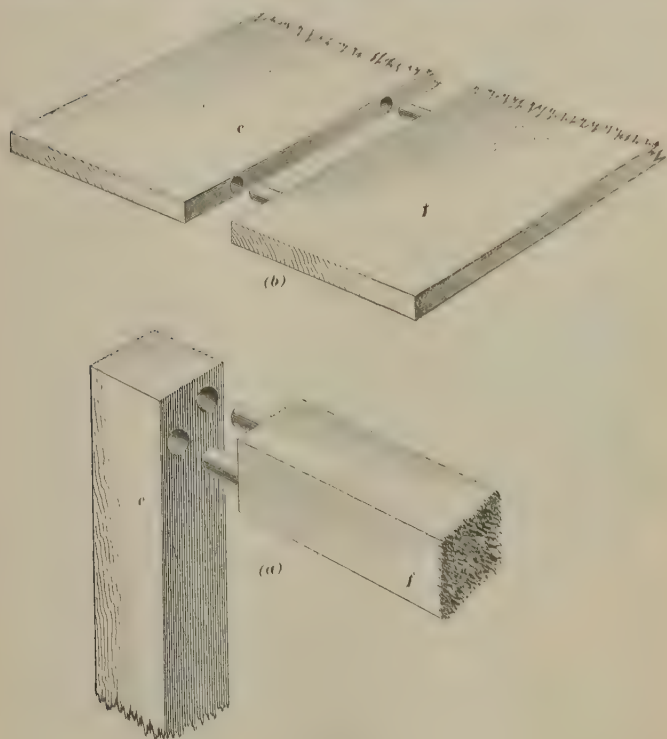


FIG. 11.

between one end and a side, as at (a), or between the two meeting edges, as at (b). Holes are bored and dowels are glued and inserted as shown. The object of the dowels is

to keep the faces flush, and render the joint stiffer if subjected to a transverse strain. The holes should be somewhat deeper than the length of the dowels, to allow for shrinkage of the material and at the same time insure a close joint. The form shown at (*a*) is a substitute for a mortise-and-tenon joint, but is not to be recommended.

17. The **mortise-and-tenon** joint as used in joinery is precisely the same in principle as the same joint in carpentry but the fitting is much more accurate. This joint, in varied forms, is used to secure the rails and stiles of doors and windows, to unite the members of heavy machine frames, and to connect the various parts of tables, chairs, and other pieces of furniture.

18. Keys and Keying.—When broad, plain surfaces, such as dados, window backs, table tops, etc., are required, the boards forming them are generally tongued-and-grooved together, or they are doweled and united with glue; but,

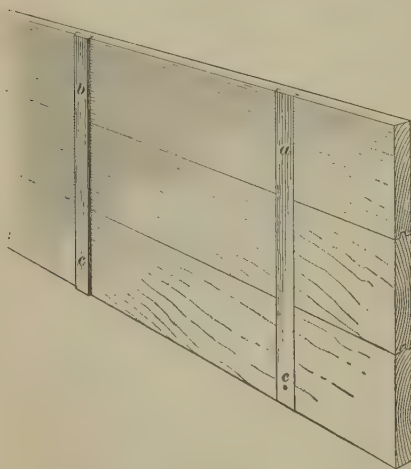


FIG. 12.

to secure the surface against warping or twisting, pieces of wood called *keys* are let into a dovetailed groove in the back, as shown at *a*, Fig. 12. These keys are either planed off flush with the surface into which they are sunk, or, when extra strength is required, they may stand up from the back, as shown at *b*. They should not be glued in position, but are sometimes se-

cured with a single screw or nail at one end, as shown at *c*, so that when the material shrinks it will slide upon the key, and the joint along the keyway or groove will still remain tight.

19. Clamping.—Boards are sometimes maintained against warping by means of clamping, as shown in Fig. 13. The boards *a* and *b* are doweled or tongued-and-grooved together on their interior edges to form a close joint, as at *c d*, and the clamps *h, j* are glued over tongues worked on the ends of *a* and *b*, as shown at *e*.

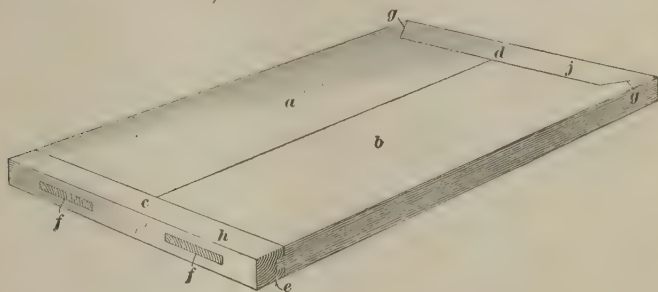


FIG. 13.

In first-class work, tenons *f* are also worked on *a* and *b*, and by insertion in the mortises in the clamp *h* strengthen the joint materially. When it is undesirable to show the end grain of the clamp, as at *e*, or of the tenons, as at *f*, the ends of the clamps are mitered off as shown at *g*, and the tenons are not permitted to extend entirely through the clamp.

Tenons and mitered clamps can only be satisfactorily used when the material is thoroughly seasoned, and where the finished product will not be subjected to changes in temperature, as under these connections no provision is made for expansion and contraction.

GENERAL JOINERY.

PROVISION FOR EXPANSION AND CONTRACTION.

20. All joiners' work that is not framed or "built up" should be so fixed that it is free to expand and contract. In a broad surface, such as a plain wainscot, this is accomplished by securing one edge only and permitting the other to rest in a groove, but in such a position that it may

contract as the wood shrinks, or expand when affected by dampness.

All wood is subject to a change in width across the grain, and when both edges are secured, shrinkage will cause the wood to split, and when dampness causes it to swell, it will either bulge in the middle or push the securing nails or screws out of place.

It may here be noted that a thorough knowledge of the properties of various woods is even more important in joiners' work than in carpentry. The slightest tendency of the material to warp, shrink, or swell must be fully compensated or prevented; for, however well seasoned the wood may be, it will always shrink somewhat across the grain when exposed to the warm, dry atmosphere of a dwelling house, and unless properly secured, thin panels will surely warp. For this reason, narrow boards are always to be preferred to wide ones, as the shrinking is distributed over a larger number of joints and is less perceptible; and, if the narrow strips are properly placed with respect to their original position in the tree, the tendency to warp may be largely compensated.

INTERIOR TRIM.

21. It is the work of the joiner to apply the door and window casings, baseboards or skirtings, wainscoting, chair rails, paneled jambs, etc., and to hang the doors, sashes, transoms, etc., which fit into the openings he has trimmed or cased.

Grounds should be placed by the carpenter around the margins of all openings, along the lower edge of the side walls, and wherever necessary to secure any portion of the interior trim.

22. *Architrave* is a term given to a casing, having a back-band, used around door and window openings, and so placed as to conceal the joint between the wood ground and plaster. Thus in Fig. 27 (*b*), *c* is the architrave covering the ground *a* and plaster *b*. Architraves are sometimes

richly molded or elaborately carved, but, except in specially designed work, it is considered better taste to keep them as simple and plain as possible.

23. Where casings extend to the floor, they must be thick enough to receive the end of the skirting *c'*, or they may stand upon *plinth blocks a*, as shown in Fig. 21, which project beyond the casings and form both a base to the door trim and a stop for the skirting *c*. The architrave is attached to the ground *a*, Fig. 27 (*b*), after the plastering is thoroughly dry, and is so placed that its outside edge will extend well over and cover the joint between the plastering and the ground.

24. The upper corners of the architrave may be joined in several ways. They may be mitered, as shown at *e*, Fig. 27 (*a*), or, when the surfaces are plain, they may be butted, as shown in Fig. 27 (*f*). When the architrave consists of both plain and molded surfaces, it should be joined by both butted and mitered joints, as shown at (*g*). Sometimes, in cheap work, corner blocks are used to stop the trim against, as shown at (*h*). These, however, are not to be recommended, not only on account of their inartistic appearance, but also on account of their tendency to shrink and leave unsightly cracks on both sides of the doorway. The architraves should be securely nailed both to the ground and to the jamb or lining all around the opening.

25. The **bases or skirtings** of a room consist of a band composed of one or more boards from 6 inches to 18 inches wide, running around the bottom of the walls, to protect the plaster.

The skirting board may be plain, or it may have a molding worked on it, as at (*a*), Fig. 14, or it may consist of a plain board with moldings applied independently to give it a finish, as shown at (*b*), Fig. 14.

When the skirting is very wide, and is made up of more than one width of boards, it is sometimes desirable to have the lower member *c* project beyond the upper one, thus

forming a sort of plinth around the room, as shown at *c*, Fig. 14 (*b*). The clearance at *f* should be from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch in rooms which are likely to be carpeted, as the edge

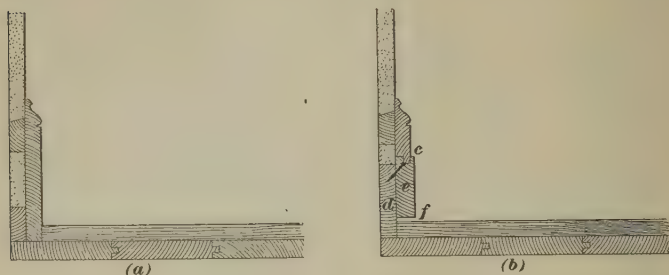


FIG. 14.

of the carpets may then be pushed under it and secured to the floor. When floors are finished with parquet work, etc., the joint between the base and the floor should be as close as possible.

26. Dados and Wainscots.—In some rooms where there is likelihood of much changing of the position of the furniture, such as the dining room, kitchen, library, etc., as well as in the bath room, halls, stairways, etc., it is sometimes desirable to affix a broad band or molding against the wall, about 3 feet from the floor and parallel to the skirting, to prevent the backs of the chairs from marring the plaster, and at the same time to form a cap to the dado or wainscot if such is desirable. This chair rail is affixed to a narrow ground, and should, of course, cover the joint between the ground and the plaster. The interval between the chair rail and the skirting is called the *dado*, or *wainscot*. It may be paneled in wood, covered with narrow lining, or simply left plain in plaster.

27. In a paneled wainscot, such as is shown in Fig. 15, great care is necessary in fitting all the joints, and due consideration must be given to the subject of shrinkage, so that the subsequent drying out of the material will not cause

unsightly cracks or open joints. The vertical pieces a , and the horizontal members b , b' , and b'' , dividing the surface of the wainscot into panels, called stiles and rails, respectively, are framed and glued together. The panels c are left free to shrink or swell to a greater or less extent, without disturbing the surrounding members. The end stiles a' extend from the floor to the top of the top rail b , and are mortised to receive the tenons of the rails b , b' , b'' , as shown at e , e' , and e'' . The rails are also mortised, and receive the tenons of the short stiles, or muntins a , a'' , as shown at f .

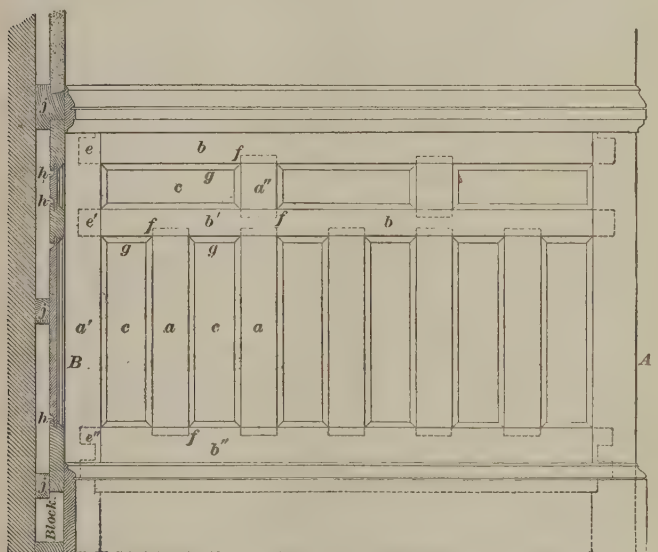


FIG. 15.

In the edge of each stile and rail a groove is worked to the depth of the molding g , and the edges of the panels c are beveled off or hollowed out and inserted in this groove, as shown at h . The moldings g when small may be worked on the edges of the stiles and rails, but when large and heavy they must be worked from separate stock and fitted in position afterwards.

The panels are thus practically separate from the surrounding frame, and are free to shrink without danger of splitting. At the same time, since the amount of cross-grain in the extent of the wainscot is equal only to the sum of the widths of all the stiles in one direction and to the widths of all the rails in the other direction, the shrinkable material is reduced to a minimum, so that the wainscot, when constructed with well seasoned material, will give good results.

28. Where the face of the wainscot is to be a plain unpaneled surface of wood, still further precautions must be taken to guard against the effects of shrinkage. Two general methods are recognized as satisfactory for the purpose of securing these large surfaces of work against the effects of warping and shrinking. One is to make the wainscot of narrow boards, not more than three times their thickness in width, with the grain in each piece reversed with reference to that of the adjacent one—that is, to have the heart side of the material show on each side at every second board. After being tongued-and-grooved and glued together, the boards are secured against warping by keys inserted as described in Art. **18**.

Another method is to build the wainscot with several thicknesses of thin stock, reversing the grain in each piece. This method is the better one for long, unbroken surfaces, as its shrinkage is prevented almost entirely; but, when the design of the wainscot will permit the building of a stile or pilaster every 6 or 8 feet, the narrow, keyed boards will be found to serve very satisfactorily, if a $\frac{1}{2}$ -inch space between the ends under the pilasters is left to provide room for expansion and contraction. These keyed sections, if the grain runs vertically, should be secured to the wall only in the center of their lengths, and left loose the rest of the way to come and go with atmospheric changes. If the grain runs lengthwise of the wainscot, no stiles or pilasters will be required to cover the joints, as the wainscot can be built up of one continuous piece; but the shrinkage must be provided for between the base and the coping, or surbase, and the

wainscot secured only in the center of its height, so as to allow the top and bottom to come and go.

29. After the paneling of the wainscot is completed, it is secured to the grounds, shown at *j*, Fig. 15, which were set in place to receive it, before the plastering was applied. Every possible precaution must be taken to insure the drying of the plaster, as the presence of the slightest moisture is fatal to permanent joiners' work. Under the most favorable conditions, there should be allowed at least a week to dry each of the first two coats of plaster, and the hardwood trim should not be applied for two weeks after the finished coat is spread. In damp or rainy weather much more time should be allowed. The patent prepared plasters and wall cements take less time than this to dry, and a deduction can be made when these are used, according to the rapidity of their drying, as described in *Masonry*.

30. When the wainscot is secured horizontally through its center, and allowed to shrink at the top and bottom, a horizontal ground must be provided to nail it to, and additional grounds must be provided at top and bottom to secure the coping and the base, as well as to form a backing for the upper and lower edges of the dado.

When the wainscot is secured along vertical lines every 8 or 10 feet of its length, vertical grounds must be provided, in addition to the grounds at top and bottom, as above described.

31. In laying out and spacing the stiles, rails, and panels of a wainscot, it is first necessary to prepare a long measuring rod, about 2 inches wide, through the center of which a line is drawn, as shown at *ab* in Fig. 16. The rod is then divided into a number of spaces, corresponding with the widths of the stiles and panels on one side of the line, and with the width of the rails and length of the panels on the other side. That is, the divisions in Fig. 16 which are above the line *ab*, as *cd*, *lm*, *l'm'*, etc., show the location and widths of the stiles *a* in Fig. 15, while the large divisions, as *dl*, *ml'*, etc., show the width of the panels *c*.

The divisions ef , gh , and ik below the line ab mark the widths of the rails b , b' , and b'' in Fig. 15, and the spaces fg and hi show the width and length of the panels.

The three rails b , b' , b'' are clamped together with hand screws, and the rod is then used to lay out the width of, and spacing between, the stiles; these divisions are then squared across the three rails with a square, and marked with a scratch awl or the point of a knife. The stiles are then marked in the same way, three or four at a time, and an allowance is made for the length of the tenons on the ends. In laying out the measuring rods for the spacing of the stiles and panels, it must be remembered that a stile must



FIG. 16.

exist on each end of the wainscot; and to determine the number of panels required, the width of one stile and twice the thickness of the wainscot must be subtracted from the length of the room, if the wainscot returns on two interior angles, and the remainder is divided by the sum of the widths of one panel and one stile. If, however, the wainscot returns around one exterior and one interior angle, as at A and B in Fig. 15, only the width of one stile should be deducted.

32. In Fig. 15, the length of the wall along which the wainscot is built is 3 feet 11 inches and the panels are each $4\frac{1}{2}$ inches wide; the stiles are all 3 inches wide, except the end one A , which is $3\frac{1}{2}$ inches wide. If we now subtract $3\frac{1}{2}$ inches, the width of the end stile, from 3 feet 11 inches, the length of the wall, we have 3 feet $7\frac{1}{2}$ inches of wainscot to be divided into six equal panels and six equal stiles. The combined width of a panel and stile is, therefore, $43\frac{1}{2}$ in. $\div 6 = 7\frac{1}{4}$ inches. Since the stiles are to be 3 inches wide, then $7\frac{1}{4} - 3 = 4\frac{1}{4}$ inches is the width of each panel opening. If the wall at A had returned on an interior angle, like the wall at B , we would have the end stile at A

of the same width as the stile at *B*, and we would then have deducted 3 inches, the width of one stile, $+2\frac{1}{4}$ inches, twice the thickness of the wainscot, from 3 feet 11 inches, which would give us about $6\frac{3}{32}$ inches as the width of each panel and stile combined; and, allowing 3 inches for the stiles, each panel opening would be $3\frac{3}{32}$ inches in width. The panels themselves, however, will be wider than that, as a proper allowance must be made all around for their insertion in the groove, as shown at *h*.

33. After all the mortises and tenons are cut and fitted, and each has been marked so that it can be returned to the same place to which it was fitted, the pieces of wainscot are taken apart and laid in a pile preparatory to gluing. The shoulders and checks of the mortises near the shoulders, or the tenons near the shoulders receive the glue, and the stiles are forced into the rails as soon after the glue is applied as possible. The lower stiles are glued in the bottom rail first, then their upper tenons are covered with glue in the same manner, and the middle rail *b'* is forced over them. The upper stiles are then glued into the middle rail; and finally the top rail *b* is glued in place, and the whole form is drawn together with bench clamps until the glue is thoroughly dry.

34. In all joiners' work, framed together with mortise and tenon, care must be taken to clean out the mortises thoroughly, and dust off the tenons before gluing; each tenon must be tried in the mortise to which it belongs and any unevenness removed, to insure its proper fit. All framed work should have its parts heated thoroughly before being clamped and glued together. If, when a piece of work is being clamped up, any rail or stile has a tendency to warp, then that rail or stile must be clamped in place with a bench screw under a piece of thick plank, and must so remain until the glue is dry. Care must always be taken that an extreme pressure of the clamps does not cause the work to deflect or wind, as it is exceedingly important in all kinds of paneled work that the whole face of the frame be kept in place, out of wind, until the glue is thoroughly set or dry.

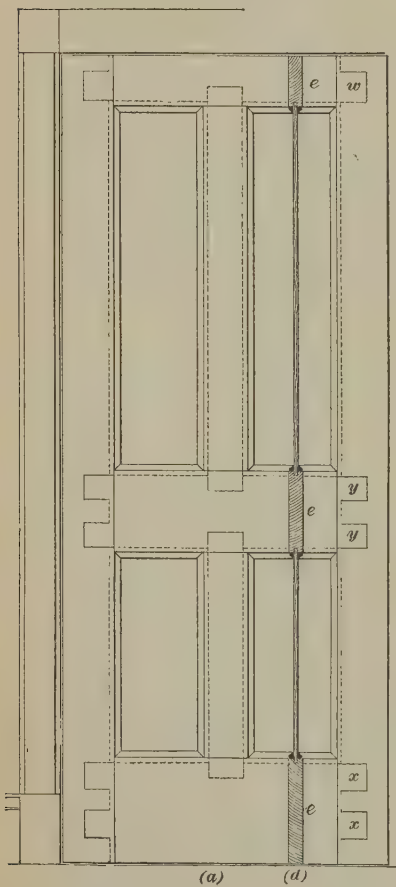
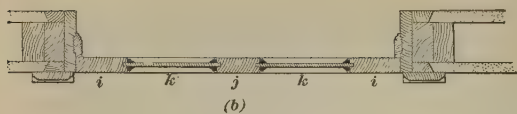


FIG. 17.

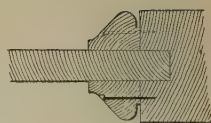


FIG. 19.

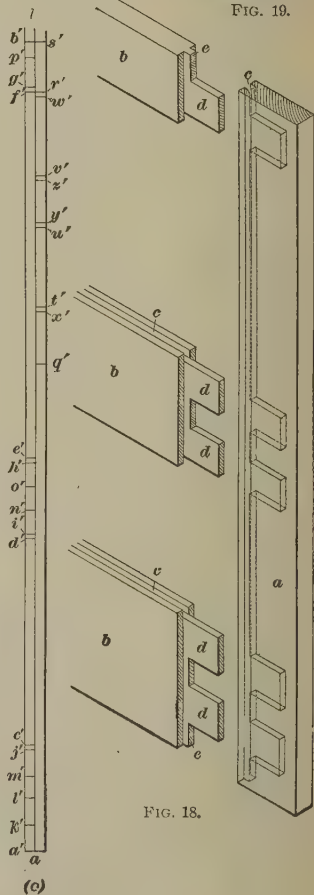


FIG. 18.

DOOR MAKING.

35. A door is a simple piece of paneled work, but the great variety of form and arrangement of its panels, and the enrichment of its moldings, together with the conditions arising from its method of opening or closing, require it to be even more securely framed and glued than a wainscot or other piece of fixed paneled work.

The swinging of a door on its hinges brings a great strain on the joints in the stile on the hinge side, whereas a sliding door hung from the top has its entire weight brought upon the joints of the top rail, or, where hung from the stile, the conditions are the same as with a hinged door.

36. In Fig. 17 (*a*) is shown a simple four-paneled door which, though devoid of any complicated framing, may be taken as a type of all doors, no matter what may be their specific design.

In laying out a paneled door, a measuring rod is first prepared, in the same manner as for a wainscot. This rod is shown in Fig. 17 (*c*), where on one side of the line ab , gauged down the middle, is laid off the distance $a'c'$ equal to the width of the bottom rail of the door. Then the distance from the bottom of the door to the top of the middle rail (or lock-rail, as it is called) is laid off at $a'e'$, and from e' is measured down the width of the lock-rail $e'd'$. Next the whole height of the door is laid off on the rod from a' to b' , and from b' is measured down the depth of the top rail $b'f'$.

As the stiles are grooved to receive the panels, a distance of $\frac{1}{2}$ inch is laid off from the upper side of the bottom rail at $c'j'$, from the under side of the top rail at $f'g'$, and from both sides of the lock-rail at $e'h'$ and $d'i'$; then we have $j'i'$ as the length of the lower panels and $h'g'$ as the length of the upper panels.

On the bottom rail $a'c'$, we have two tenons $k'l'$ and $m'j'$, each $2\frac{1}{2}$ inches wide, with $1\frac{1}{2}$ inches between them, and also $1\frac{1}{2}$ inches between the lower tenon $k'l'$ and the bottom of

the rail. The space between these tenons at $l'm'$ and $a'k'$ is provided with a short projection which passes into the stile to the bottom of the groove. This projection is called a *relish*, and its purpose is to preserve some solid wood in the groove between the mortises. The double tenons are necessary in the wide rails in order to preserve the strength of the stiles.

On the lock-rail $d'e'$, the width of the tenons is laid off at $i'n'$ and $o'h'$ with a relish preserved at $n'o'$. The tenon of the top rail is marked at $g'p'$, and $p'b'$ is left for the relish; $c'd'$ is then the length of the lower muntin between the shoulders, while $e'f'$ is the length of the upper muntin.

On the other side of the rod, at $q's'$, are laid off the proportions for the division of the widths; thus $q't'$ and $s'w'$ are each equal to the width of a stile, and exactly midway between these is laid off, at $u'v'$, the width of the muntin, and $y'z'$ is the width of the muntin at the bottom of the grooves to receive the panels. The widths $t'x'$, $u'y'$, $v'z'$, and $w'r'$ are $\frac{1}{2}$ -inch allowances for the grooves in the stiles and muntins, and at $x'y'$ and $z'r'$ is shown the extreme width of the panels. The mortises and relishes are also here shown as on the other side of the rod.

37. A horizontal section of this door and trim, showing the details of construction, is shown in Fig. 17 (*b*). At i, i are shown the stiles laid off on the measuring rod at $q't'$ and $w's'$, and at j is the muntin marked on the measuring rod at $u'v'$; k, k are the panels inserted in the grooves of the stiles and muntin, which grooves were provided for on the measuring rod at $x't'$, $u'y'$, $z'v'$, and $w'r'$.

A vertical section of the door is shown in Fig. 17 (*d*), where c, e, e are the three rails, grooved as provided for on the measuring rod. The elevation of the door, Fig. 17 (*a*), shows the tenons of the bottom rail where they enter the mortise of the stile at x, x , the tenons of the lock-rail at y, y , and the single tenon on the top rail at w . The dotted lines show the grooves in the stiles, rails, and muntins, and the relishes between and beyond the tenons.

At *a*, Fig. 18, is shown a perspective view of one of the stiles; at *b, b*, the ends of the rails; at *c, c*, the grooves for the panels and relishes; and at *d* and *e*, the tenons and relishes.

38. When the measurements for the door are all laid out on the rod, the stiles and rails for all doors of one pattern are cut out of well seasoned stock of proper thickness, and each member is then carefully planed and marked on its *jointed edge*. The rails are cut to their full lengths including tenons, and the stiles are cut about 4 inches to 6 inches longer than is required; when all the rails and stiles are cut, a set for one door is then taken, and the grooves for the panels are plowed as shown at *c*, Fig. 18. The mortises and tenons are cut and accurately fitted one at a time, and each is marked for the place for which it is intended. Or, where a number of doors are exactly alike, a half dozen or more rails or stiles of one kind may be taken, placed side by side, clamped tightly and marked for their respective mortises and tenons at one operation. The door now having been made and the tenons carefully fitted to their respective mortises, the door is put together without glue or other fastening, and left until immediately before it is required to be fixed in the building, in order that it may have as long a time as possible to season.

Before being glued, the door is taken apart, the mortises are cleaned; the tenons are spread with glue on their shoulder ends, and after the panels are inserted the whole is driven close with a heavy mallet, laid on a pair of trestles, and secured, until the glue is dry, by means of bench clamps, one of which is placed opposite each rail.

39. In strictly first-class work, the mortises and tenons do not extend entirely through the width of the stile, but are let in only from $\frac{2}{3}$ to $\frac{3}{4}$ the width, as shown at *w, x*, and *y*, Fig. 17 (*a*). But, in cheaper work and in some "machine-made" doors, the tenons extend entirely through the stile and are wedged up from the outside to render them tight. In such cases, the mortise is made from $\frac{1}{4}$ to $\frac{1}{2}$ inch larger on

the outside than on the inside, and the tenon is then, by means of a couple of wedges, expanded to a dovetail form. Sometimes the wedges are driven above and below the tenons, and are glued in place to make the whole joint tight and secure.

40. The proportions of the panels, and the details of the design of the panels and moldings of doors, are subject to great variation. The lock-rail, however, should always be in a position not too low for one to be able to reach the lock without stooping, nor too high for a person to grasp the knob without reaching. The standard height to the center of the knob of the lock has been fixed at 3 feet from the floor. The lock should be mortised into the stile *between* the tenons of the lock-rail, or immediately above them, in

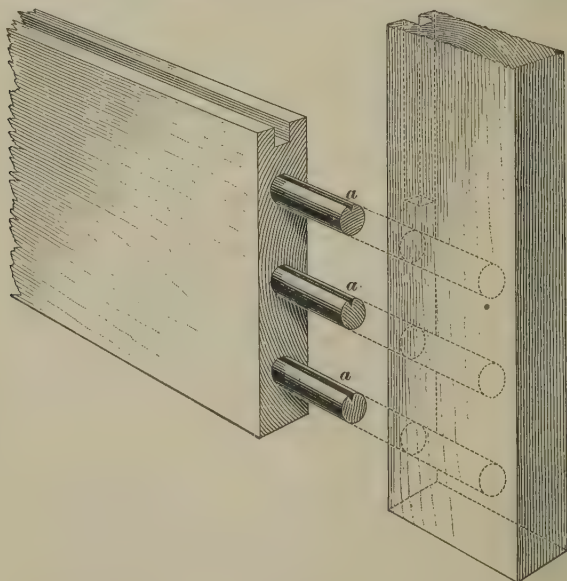


FIG. 20.

order not to destroy these tenons when the lock is inserted. A preferable method is to put in a lock-panel from 6 inches

to 7 inches wide in place of the lock-rail; this is accomplished by practically cutting the lock-rail in two in the width and inserting a panel between the sections, as shown in Figs. 21 and 22.

41. The moldings around the panels of doors may be a simple ogee, worked on the edges of the stiles and rails, or they may be inserted in the angle between the edge of the stile or rail and the panel, as shown in Fig. 19, care being taken to see that the nails pass into the edges of the framing (and not into the panels), as suggested in the figure.

42. In some foreign countries, and in certain localities of America, the stiles and rails of panel work are put together with dowels, as shown in Fig. 20. These dowels vary from $\frac{3}{8}$ inch to 1 inch in diameter, according to the thickness of the wood to be united, but in any case they are considerably thicker than a mortise would be in the same material. Along the edge of each dowel, a **V**-shaped groove is cut, as shown at *a*, to allow the air and surplus glue to escape when the parts are driven together.

43. **Sliding doors** differ from ordinary swing doors chiefly in the method of hanging them, and, as the strain of their parts is reduced or increased with the different methods, a corresponding alteration of the details of their framing is necessary. Fig. 21 (*a*) shows one of a pair of sliding doors, which is intended to be hung from the top, as the stile is not then subjected to as great a strain as when the door is hung on the side. Where a sliding door is hung with the patent stile hanger, which brings the entire weight upon the stile, particular attention must be given the mortises and tenons in the hanging stile to insure their perfect fit, as the slightest loosening would cause a sag in the door, which would prevent it from running smoothly.

In the plan of this door, shown at (*b*), the meeting stiles of both doors are shown, and, as will be seen, the edges of the rails are worked to fit together in a shallow tongued-and-grooved joint. This preserves the alinement of the doors

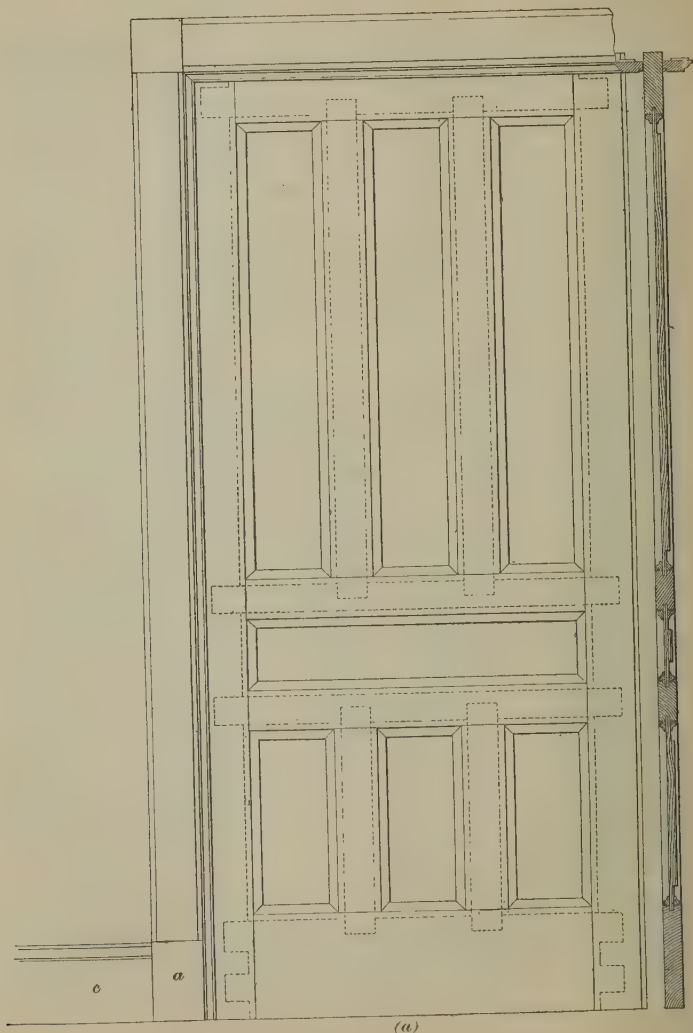
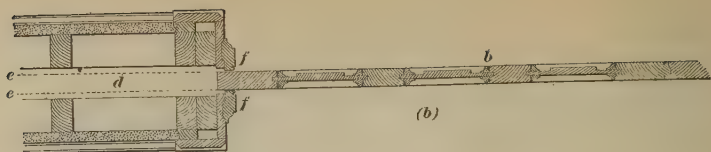


FIG. 21.

when closed, and tends to prevent the appearance of a slit, or crack, between them, as would be the case if they simply butted together.

In opening, the doors slide into a pocket built in the partition, as shown at *d'*, the dotted lines *c* showing the position of the door when it is in the pocket. This pocket is framed and finished in the same manner as a simple studded partition, except that the studs are set in two rows with a space between them, at *d'*, about $1\frac{1}{2}$ inches to 2 inches wider than the door is thick. The jambs of the door opening are then finished with a molded trim, which is let into the jamb, as shown at *f*, and is allowed to project over the end of the pocket to within $\frac{1}{4}$ inch of the door. A stop is provided within the pocket *d'*, to prevent the door from sliding too far into the opening. The hardware on the meeting stiles of the door must be sunk flush with the face of the stile, so that it will not prevent the door from sliding clearly into the pocket. Numerous sliding-door locks and catches are provided by the hardware dealers, made specially for this style of door.

44. Folding doors consist of a pair of single doors hinged on opposite sides of the opening, and provided with a stop-bead or rabbeted stile, so that they will close together in a tight joint at the middle of the opening. Fig. 22 shows a plan (*a*) and an elevation (*b*) of a pair of folding doors which are arranged to meet the requirements of the outside vestibule-entrance doors, or storm doors as they are sometimes termed, of a frame dwelling. When this form of door is used as an inside vestibule door or a direct-entrance door, the panels *b*, as shown at *o* in the section *B''*, taken on the line *B B'* of the elevation, are usually of glass, but in the former case the transom only may be glazed, to admit light to the vestibule when both doors are closed. The sectional plan *A''* of the door is taken on the line *A A'*, and shows the two lower panels at *p*. The framing of the stiles and rails of folding doors is precisely the same as for single swing doors, but the meeting stiles must

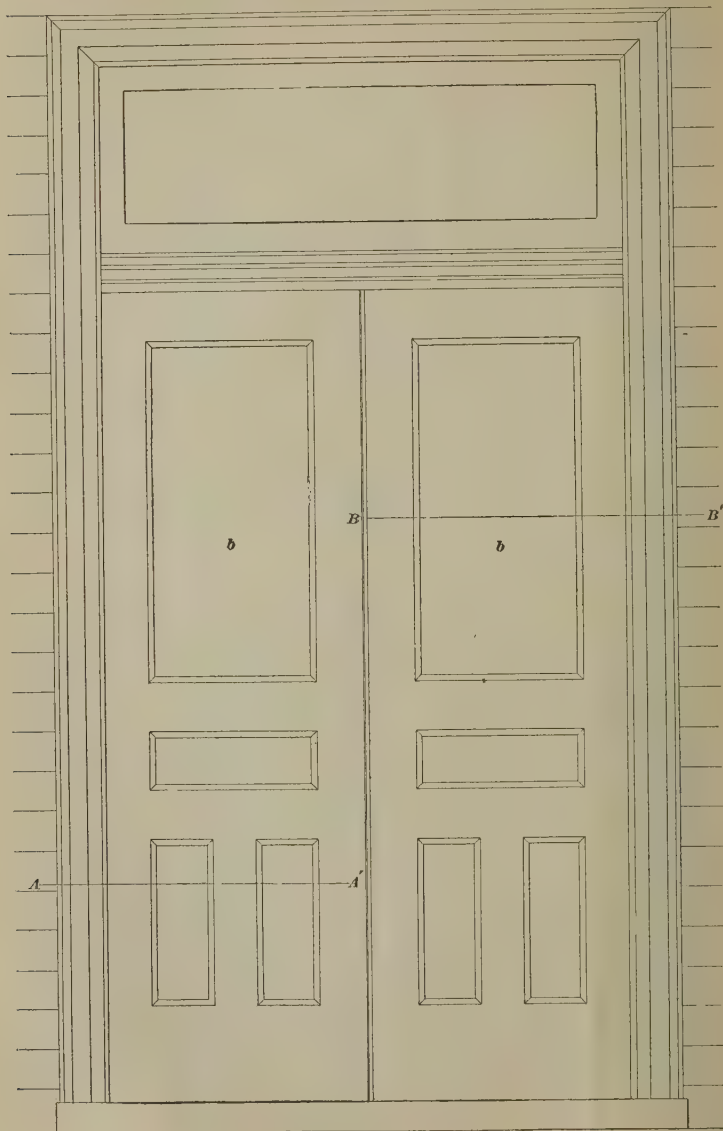
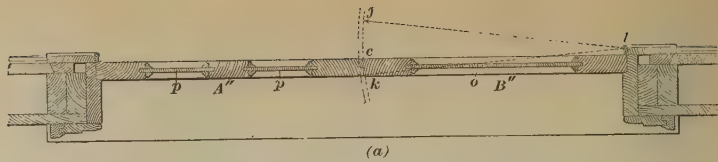


FIG. 92.

be rabbeted, as shown at *c*, so as to provide a stop against which the more frequently used door may close.

This rabbeted stop must be beveled off slightly on the inside, to give proper clearance to the outside angle of the door when it is opened. The amount of bevel necessary in order to accomplish this clearance is found by striking a circular arc *j'k* with a radius *kl* equal to the diagonal distance from the corner *k* of the door to be cleared to the center of the butt pin *l*, and with a center at the latter point.

WINDOWS.

45. In the construction of a building, openings are left in the walls which are subsequently to be provided with some form of window frame and sash. The particular form in each case will depend upon the character of the building and the purposes for which the windows are required. In residence structures, the main object is to secure proper light and ventilation, and some form of sash window is used; while in stores and some warehouses, the first-story windows are usually arranged for the display of goods exposed for sale, and the window assumes the character of a glass case without sashes or frames, except such as are necessary to hold the glass in place.

46. Sash windows may be divided into two general classes, namely, *fixed* sashes and *movable* sashes, and the latter class may be hinged, pivoted, or balanced, as the case may require. Window sashes vary in thickness according to their size, but in ordinary frame dwellings they seldom exceed $1\frac{3}{4}$ inches. The frames for these windows are generally built in the walls as the building is carried up, and are differently constructed, according to the character of sash they are to carry and the material of the wall in which they are inserted.

47. In Fig. 23 is shown the construction of a window frame for an ordinary frame dwelling. At (*a*) is the section through one side of the frame showing the stud at the side

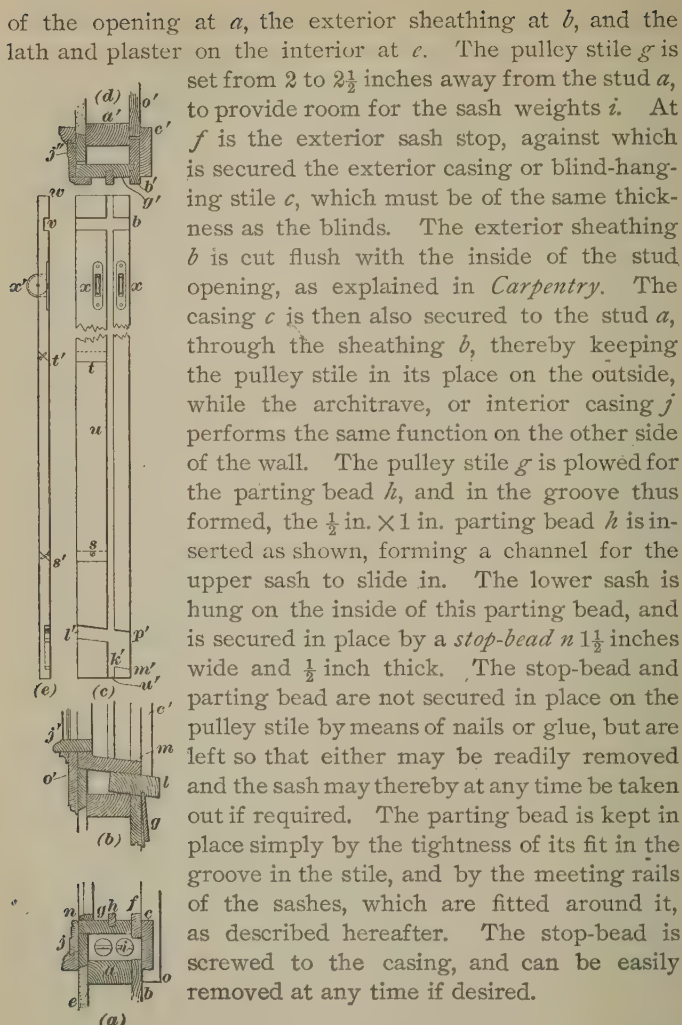


FIG. 23.

48. At (b) is shown a vertical section of the frame through the sill, and other details of the lower part of the window. The sill *m* is inclined at a pitch of

about $1\frac{1}{2}$ inches to the foot, and its outer edge rests upon the 2-inch sub-sill l , which is inclined at a similar angle, and has its under side grooved to receive the upper edge of the clapboards g or shingles covering the side of the house. At o' is shown the inside casing, or *apron*, as it is frequently termed, which is attached to the back of the sill m , and which with the sill cap forms the inside finish of the lower part of the window. The inside casing, or architrave, j' , as shown in the sectional plan at j , rests upon the sill cap. The sub-sill l is the detail that forms the bottom of the window on the outside of the house; upon it rests the exterior casing c' , which is seen in the sectional plan at c , and which frames the window opening on the outside, in the same manner as does the trim j' on the inside. The sill and sill cap are both carried beyond the casings c and j , and are returned around them and against the walls, as shown at o in the plan (α).

49. At (c) is shown the elevation of the inside face of one of the pulley stiles. The lower part of the pulley stile $l' m'$ is cut out to receive the ends of the sill and sub-sill—the sill extending through the entire thickness of the stile from l' to p' , and the sub-sill extending from k' about 2 inches beyond the face of the stile at m' . The $\frac{1}{2}" \times \frac{1}{2}"$ groove plowed to receive the parting strip h , is shown at u . The depth of the cut-out portion $l' p' m' k'$ is equal to the depth of the groove u , and as shown at u' , the groove extends to the bottom of the stile. The upper part of the pulley stile is grooved at b to receive the window head, immediately below which are placed the two pulleys x, x , one for each sash. These pulleys are let into the face of the stile so that the face plates are flush with the inside of the frame, but the wheels extend through to the interior, as shown at x' , in the side elevation (c) of the stile. The depth of the groove to receive the window head is $\frac{1}{2}$ inch, as shown at v ; the material from v to w extends 2 inches above the window head, to permit the fitting of the frame to the stud opening.

At $s t$ in the elevation (c) is shown an opening to the weight box known as the *pocket*. This opening is cut out to permit

easy access to the weights, in case of renewal of the sash cords, and is closed by means of a bevel-edged board secured in place by screws. In the elevation of the pulley stile at (*e*), the pocket cover is shown at *s' t'*, as well as the lines on which the ends are beveled to secure the desired fit. The upper bevel at *t'* is notched over the shank and under the head of a screw inserted in the back of the stile, as shown at *t'*. The lower bevel *s'* is then secured against the bevel of the pocket by means of a screw driven straight through the face of the cover, as shown at *s* in the elevation (*c*).

50. At (*d'*) is shown a section through the window head at the center of the opening. Here the stud *a'* is shown in its position at the top of the frame opening, while the window head *g'* is shown 2 inches below; these 2 inches permit projections of the stiles, shown in (*c*) at *vw*, to be fitted to the top of the opening. The inside trim *j''* is then secured across the opening between the casing *g'* and the stud *a'*, and the outside trim *c'* is laid over the exterior casing *b'* and extends to the sheathing at the edge of the framed opening

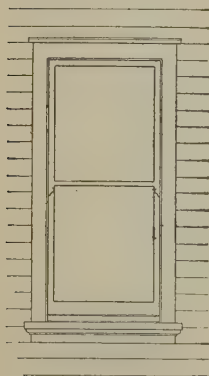


FIG. 24.

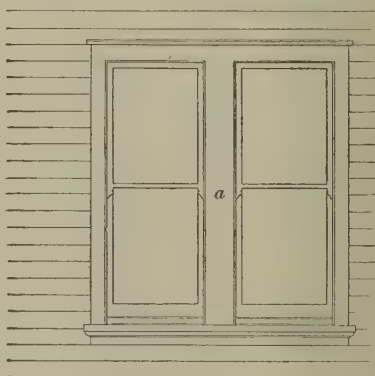


FIG. 25.

at *o'*. A cap member should be placed over the upper edge of the casing to shed the water, or a cap flashing of copper or lead may be used.

This practically completes the description of the details of the frame for any single window in a frame building such as shown in Fig. 24; when, however, windows are coupled in pairs or triplets, a dividing member, called a *mullion*, must be included in the frame, as shown at *a* in Fig. 25.

51. A *mullion* is simply a division placed between two sashes. With sliding sashes it must contain the weight box for their inner edges, but with hinged sashes it need be no more than a bar, against which the sashes may close, and upon which they may be hinged. The former kind is illustrated in Fig. 26, which shows a horizontal section through the mullion *a* in Fig. 25.

Inasmuch as the mullion may contain four weights (two for each pair of sashes), instead of two weights as in the box of a single window, the inside trim *a* and the outside trim *c* must be somewhat wider than the same details are in a single frame.

The pulley stiles *b*, the stop-beads *c*, and the parting strips *a* are detailed in precisely the same manner as in a single frame, but the distance between the stiles *b* being from 4 to 5 inches, in order to accommodate the weights *d*, the casings require to be proportionately wider to cover the joints. The pocket in the pulley stile may exist on one side of the mullion only, as access to all four weights can thereby be readily attained. The sill of the window, however, is not gained into the pulley stile of the mullion, as is the case with the single frame shown in Fig. 23. Instead, the sill and the window head each extend as one piece across both openings, and each is grooved to receive the mullion pulley stiles.

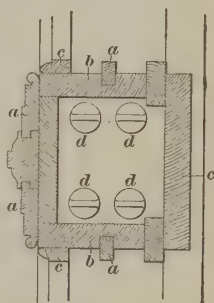


FIG. 26.

52. When a window frame is required for insertion in the opening of a brick or stone wall, the details shown in Fig. 23 must be considerably altered in order to make the

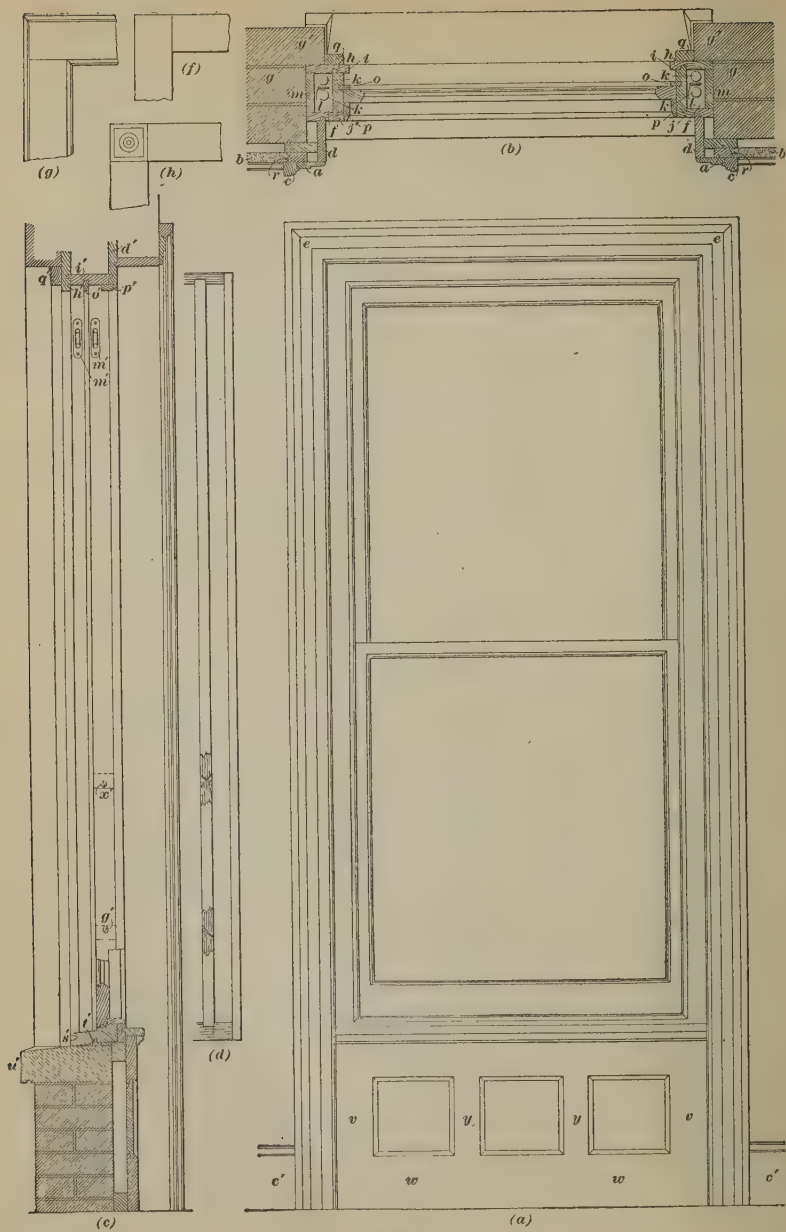


FIG. 27.

frame fulfil the requirements. Fig. 27 shows at (*a*) the interior elevation of such a window; at (*b*), a horizontal section; at (*c*), a vertical section; and at (*d*), a section through one of its pulley stiles. In the horizontal section (*b*) the weight boxes with the details of their construction are shown at *f*. The brick wall *g* is 12 inches thick, with a reveal at *g'* of 4 inches. At *h* is shown the outside lining, into a groove of which is tongued the pulley stile *i*, which in turn is, in a similar manner, let into the inside lining *j*. These three pieces form a box *f*, in which are hung the two sash weights *k*, separated by a wooden tongue *l*, to prevent them striking together when the sash is raised or lowered. The weight box is closed by the back lining *m*. The pulley stile *i* is grooved to receive the parting bead *o*, which, with the $\frac{1}{2}$ -inch or $\frac{5}{8}$ -inch projection of the outside lining *h*, secures the upper sash in its place and provides a *way* in which it may slide. The parting bead may be of hardwood from $\frac{1}{2}$ in. $\times$ 1 in. to $\frac{5}{8}$ in. $\times$ $1\frac{1}{4}$ in. section. The lower sash slides inside of the parting bead and is secured in place by means of the stop-bead *p*.

In the angle between the outside lining *h* and the brick reveal *g'*, is placed a casing *q* to which outside blinds or shutters may be hung, though sometimes it is of some special design. The jamb lining *d* is secured to the inside lining *j*, and extends to the floor; the architrave, or trim *c*, is attached to it, and by covering the ground, binds the plaster joint at *r*.

The top of the window frame is shown in Fig. 27 (*c*). Here the exterior casing or angle mold is mitered in the corner and is carried across the top of the window as shown at *q'*, while the outside lining is butted in the corner and carried across the top of the opening, as shown at *h'*. The window head *i'* is let into the pulley stiles and plowed to receive the parting strip *o'*. The stop-bead *p'* is mitered in the angle and returned across the top of the frame, covering the joint between the window head *i'* and the inside casing *d'*. The pulleys *m'* are the same as in the former case, and the pocket, as shown at *x' g'*, gives access to the weights.

The sill s' in this case rests its outer edge on the stone sill u' instead of on a wooden sub-sill, as in the previous example. There is also a break or step in the thickness of the sill where the stop-bead meets it. When set, the sill is laid on a bed of mortar spread over the stone sill u' , and this mortar, being forced up into the groove shown at t' , makes a perfectly water-tight joint between the two sills.

From the sill to the floor, on the inside of the window, the wall is covered by a *panel back*, or breast, as shown in the elevation (a) at w . The stiles, rails, and muntins of this panel back are grooved on their edges and mortised and tenoned together, as are also the same details in the doors. The lower rail is scribed to the floor, and the upper rail is capped by the wooden sill of the window, as shown in the section (c). A molding is then set into the angle between the sill of the window and the rail of the panel back, and finishes the joint. The stiles of the panel back are considerably wider than shown at (a), as they extend beyond and behind the jamb lining.

53. Sashes vary slightly in their construction, according to the manner in which they are hung, and the character of the building for which they are intended. Sashes of ordinary dimensions are from $1\frac{1}{2}$ inches to 2 inches in thickness, with the bottom rail $3\frac{1}{2}$ inches to 4 inches in width, while the stiles and top rail are 2 inches in width. The meeting rails of double-hung sashes are usually $1\frac{1}{2}$ inches wide, and are beveled, as hereafter described, to insure a tight joint.

Sashes which are to be glazed with heavy plate glass should be at least 2 inches thick, and should have a bottom rail 4 or 5 inches wide.

The outside dimensions of window sashes are dependent very largely upon the regular market sizes of glass, it being economical to use glass in sizes that can be procured without cutting to waste.

A table of the sizes of window glass and the number of panes in a box is given herewith; a box being supposed to contain 50 square feet of glass.

TABLE OF SIZES AND NUMBER OF PANES IN A BOX OF WINDOW GLASS.

Size in Inches.	Panes in Box.	Size in Inches.	Panes in Box.	Size in Inches.	Panes in Box.	Size in Inches.	Panes in Box.
6×8	150	12×19	32	16×20	23	24×44	7
7×9	115	12×20	30	16×22	20	24×50	6
8×10	90	12×21	29	16×24	19	24×56	5
8×11	82	12×22	27	16×30	15	26×36	8
8×12	75	12×23	26	16×36	12	26×40	7
9×10	80	12×24	25	16×40	11	26×48	6
9×11	72	13×14	40	18×20	20	26×54	5
9×12	67	13×15	37	18×22	18	28×34	8
9×13	62	13×16	35	18×24	17	28×40	6
9×14	57	13×17	33	18×26	15	28×46	6
9×15	53	13×18	31	18×34	12	28×50	5
9×16	50	13×19	29	18×36	11	30×40	6
10×10	72	13×20	28	18×40	10	30×44	4
10×12	60	13×21	26	18×44	9	30×48	5
10×13	55	13×22	25	20×22	16	30×54	5
10×14	52	13×24	23	20×24	15	32×42	5
10×15	48	14×15	34	20×25	14	32×44	5
10×16	45	14×16	32	20×26	14	32×46	5
10×17	42	14×18	29	20×28	13	32×48	5
10×18	40	14×19	27	20×30	12	32×50	4
11×11	59	14×20	26	20×34	11	32×54	4
11×12	55	14×22	23	20×36	10	32×56	4
11×13	50	14×24	22	20×40	9	32×60	4
11×14	47	14×28	18	20×44	8	34×40	5
11×15	44	14×32	16	20×50	7	34×44	5
11×16	41	14×36	14	22×24	14	34×46	5
11×17	39	14×40	13	22×26	13	34×50	4
11×18	36	15×16	30	22×28	12	34×52	4
12×12	50	15×18	27	22×36	9	34×56	4
12×13	46	15×20	24	22×40	8	36×44	5
12×14	43	15×22	22	22×50	7	36×50	4
12×15	40	15×24	20	24×28	11	36×56	4
12×16	38	15×30	16	24×30	10	36×60	3
12×17	35	15×32	15	24×32	9	36×64	3
12×18	33	16×18	25	24×36	8	40×60	3

54. Large plate-glass windows are usually designed to have the sash pivoted at the center of the top and bottom

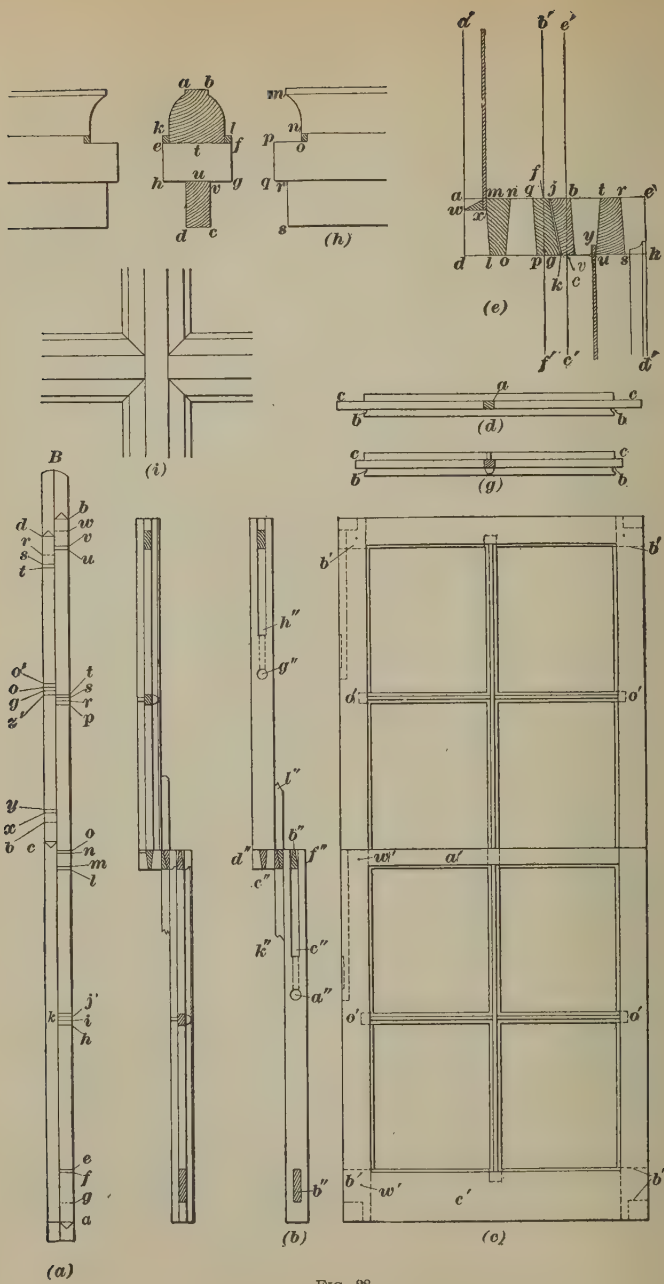


FIG. 28.

rail, if the sash is for one pane, and is too heavy to balance with weights; or, if a muntin or pair of meeting stiles down the center is not an objectionable feature, the sash may be of the form known as the French casements, where the two sashes are hinged to the frame and meet and lock together in the middle like a pair of folding doors.

55. Sash making, like all framed work in joinery, is preceded by the preparation of a measuring rod, upon which are laid out the various dimensions. Fig. 28 shows a pair of sashes for a double-hung window, the lights of which are to be 8 in. $\times$ 10 in. A rod of proper length, as shown at (*a*), is first prepared as follows: On one side of the central dividing line is laid off the distance *ae*, equal to the width of the bottom rail, which in this case is $3\frac{1}{2}$ inches. From *e* to *f* is then laid off $\frac{3}{16}$ inch for the rabbet, and from *f* to *i* is measured $10\frac{1}{16}$ inches for glass; *ih* is then laid off $\frac{3}{16}$ inch for rabbet, and *ij* is laid off $\frac{1}{2}$ inch for the tongue of the astragal; *kj* is then made $\frac{3}{16}$ inch for rabbet, and *jm* is laid off $10\frac{1}{16}$ inches for glass. The $\frac{3}{16}$ -inch rabbet is then again laid off from *m* to *l*, and *lo* is $1\frac{1}{2}$ inches for the meeting rail. The upper sash is then laid out in the same way—a rabbet of $\frac{3}{16}$ inch at *on*, an opening for glass of $10\frac{1}{16}$ inches at *nr*, another $\frac{3}{16}$ -inch rabbet *rp*, a $\frac{1}{2}$ -inch tongue *rs*, a rabbet *ts*, a light *sv*, and a top rabbet *vu*; *ub* is then made 2 inches for the width of the top rail. The top and bottom rails are tenoned into the stiles, and *ag* and *bw* are laid out on the rod for a relish.

On the other side of the bar, from *c* to *d*, the divisions of the width are laid off in the same manner; *dt* and *cy* are each made 2 inches for the width of the stiles, *ts* and *yx* are then laid off for rabbet, and *tr* and *yb* are each made $\frac{1}{2}$ inch for the length of the tenon on the astragals; *so* and *xg* are then made $8\frac{1}{16}$ inches for glass and the tongue *og* is made $\frac{1}{2}$ inch.

56. At (*b*) is shown the side elevation, and at (*c*) the interior elevation of the two sashes in their relative positions. The upper and lower rails *a'* and *c'* are tenoned into a

mortise in each stile, as shown dotted at b' , and are secured by means of $\frac{5}{16}$ -inch pins w' . The tenons extend all the way through the stiles, and are seen on the side of the sash shown at b'' . The astragals are also tenoned into a mortise sunk into each stile, but extending only $\frac{1}{2}$ inch into the wood, as shown at o' . The meeting rails are dovetailed to the stiles, as shown in the side elevation (b), at $f'' d''$, and the vertical astragals are mortised into the top and bottom rails, and are themselves mortised to receive the tenons of the cross-bars, as described below.

At (d) is shown the top edge of the lower rail, in the center of which is sunk the mortise a for the astragal; on the ends are seen the tenons c , which are to fit the mortises in the stiles. The molding on the inside of the rail is not mitered in the angle, but is coped over the stile molding, as shown at b and described hereafter.

57. At (e) is shown a section through the meeting rails, which illustrates the method of cutting the dovetails on the stiles to insure a satisfactory joint. The two meeting rails are first planed down to a section of $1\frac{1}{4}$ in. $\times$ $2\frac{1}{4}$ in., which would cause them to occupy the positions shown at $abcd$ and $efgh$, but they are afterwards beveled off on the line jk , as explained hereafter. The lower ends of the stiles of the upper sash, and the upper ends of the stiles of the lower sash, are then dovetailed as shown at $adlm$ and $nopq$ and at $sreh$ and $vbtu$; the dovetail pins $lmno$ and $utrs$ are then cut on the meeting rails, and insure a joint which will be unlikely to work loose or shrink out of place after the sashes are hung. On the outside of the lower rail of the upper sash, a rabbet wxm is cut to receive the glass; and on the under side of the upper rail of the lower sash, a groove uy is plowed, to receive the upper edge of the glass in this lower sash.

The thickness of the stiles of the sash is only $1\frac{3}{4}$ inches from a' to b' or from c' to d' , while, as stated before, the meeting rail extends nearly $\frac{1}{2}$ inch beyond this, or close to the edge of the parting strip. When the sashes are hung,

the edge of each meeting rail is planed off to the line $j'k$; so that, when the sashes are closed in the position shown in the illustration, the beveled edges will act as a wedge, and by insuring a tight joint will tend to prevent the sashes from rattling.

58. At (*g*) is shown a plan of one of the horizontal bars mortised into a vertical one, thus dividing the sash into four parts. At *c* is shown the projection of the tenon which enters the mortise in the side of the sash, while the molding on the sash bar is cut out to cope over the molding on the stile as shown at *b*. The vertical bar is also similarly coped and mortised into the top and bottom rails of each sash, while at its center a mortise is cut through the stuff to receive the tenon on the middle ends of the horizontal sash bar. This is more clearly shown at (*h*), where $abcd$ is a section through the vertical bar at the center of the joint. At $efgh$ is seen the portion which is cut through to receive the tenons of the sash bar, and at ek and fl are seen the mitered edges of the upper portion of the square section of the bar, which are so joined as to present a neat appearance, as well as to insure a perfect joint. The upper part of the bar mo is cut out to cope over the molded part of the bar at bl , and the tenon $opqrr$ is inserted in the mortise $efgh$, but extends only half way through it, or to the center line tu , leaving the other half of the mortise $etuh$ for the tenon on the other half of the horizontal bar.

The portion rs then butts against the rib at vc , and the whole is secured in place by the pressure of the stiles of the sash against the outer ends of the horizontal bars.

The mortising of the horizontal bars into the stiles is effected in precisely the same manner as into the vertical bar, the molded portion being coped and the solid central part let into the mortise.

59. On the side elevation (*b*) is seen at a'' a round hole, $\frac{7}{8}$ inch in diameter and $\frac{3}{4}$ inch deep, bored in the sides of each sash just above the middle, to receive the knot of the sash cord which is to extend over the pulleys to the balance

weights in the weight box. A groove is cut $\frac{1}{2}$ inch wide and $\frac{1}{2}$ inch deep at $c'' b''$ for the cord to lie in, from the top of the sash to c'' ; and a hole $\frac{3}{8}$ inch in diameter, bored from c'' to the $\frac{7}{8}$ -inch hole at a'' , as shown by the dotted lines $c'' a''$, holds the cord in place, and prevents the knot from slipping out of the hole at a'' .

At $k'' l''$ on this side elevation (*b*) is shown a portion of the parting bead in its position relative to the sashes. It will be readily seen that, as the meeting rails of the sashes extend beyond the interior and exterior faces of the upper and lower sashes respectively, the beveled portion of these rails must be notched out on the ends to fit around the parting bead.

60. When all the parts of a sash are made—stiles, rails, vertical and horizontal bars—the whole frame is drawn together with bench clamps, and wedges dipped in glue are driven in on each side of the tenons b' . The mortises are made $\frac{1}{2}$ inch wider on the outside than on the inside of the stiles, to make room for the wedges, which are driven until the joint is closed tight. Holes $\frac{1}{4}$ inch in diameter are now bored through each mortise and tenon b' and each dovetail joint, and wood dowels dipped in glue are driven through the joint to secure it, as shown at w' in the elevation (*c*). Barbed steel or iron pegs are often used instead of wood dowels. When the clamps are removed, the faces are smoothed and made ready for fitting into the frames.

61. Sashes should always receive one coat of paint before they are glazed, in order to prevent the wood from absorbing the oil from the putty with which the glass is fixed in place, and thereby rendering the putty brittle and inadhesive.

In glazing the sash, the rabbet is first prepared, by spreading a thin layer of putty along the glass bearing, to form a cushion, against which the panes of glass are first partly secured, by means of small triangular pieces of tin, called *glazing brads*, which are driven into the wood against the face of the glass. Putty is then spread in the rabbet to form a triangular fillet, and permanently hold the glass in

place. This putty extends to the outside of the rabbet and up the face of the glass to within $\frac{1}{16}$ inch of the daylight opening. The back putty which has squeezed out between the pane and the glass bearing is then scraped off flush with the daylight opening, and the sash is then set aside to await its second coat of paint.

If a pane of glass is curved slightly, it should be placed with its convex face to the weather, and, if warped so that its surface is not even, it should not be forced to a full bearing in the rabbet, but permitted to lie naturally in place, and any unevenness should be taken up in the bearings by back puttying—that is, the space between the glass and the bearing face of the rabbet is filled with a thin layer of putty, against which the uneven surface of the glass may rest.

62. To fit and hang the sash in the window frame, it is first necessary to remove the stop-bead and parting strip, and then fit the upper sash so that it slides easily between the pulley stiles. The parting strip is then replaced and the sash secured in place by nailing a couple of wooden blocks under it; the lower sash is then similarly fitted. The lower rail of the sash is then planed off until the meeting rails rest snugly together, as required.

In providing weights for the sashes, the pair for the upper sash must be at least half a pound heavier than the weight of the sash, while for the lower sash the weights must be at least half a pound less than the weight of the sash. This half-pound excess in the upper weights and in the lower sash tends to keep the sashes close and tight against the window head and the sill.

To hang the sash, the pockets must be opened by unscrewing and removing the covers. The sash cords are carried over the pulleys by means of a piece of light but strong string, which has been previously forced over the pulley and drawn down within the box with a lead weight, called a *mouse*, small enough to go over the pulley sheave, but heavy enough to carry the string. The sash cord is then made fast to the weight, and, with the top sash resting

equally on the sill, the weight is pulled up to the pulley, and the cord is cut off just long enough to permit a knot to be tied at the required point. By the use of metallic cord grips, knots on the ends of the sash cord are not required, but care must be taken to have the grip of a size to properly fit the cord. When both weights for the upper sash are thus attached, the sash is removed from the frame far enough to permit the cord to be pushed down through the groove and the hole seen at *g'' h''*, Fig. 28, and a knot is tied to prevent it from pulling out. When both weights and cords are thus attached, the sash is replaced in the frame, pushed up and down a few times to test its efficiency, and the lower sash is then hung in a similar manner. When the sashes are both hung, and are found to slide satisfactorily, the stop-bead is replaced and secured, and the pocket is closed and screwed up tight, to prevent the cover from catching on the lower sash.

63. Hinged sashes are, as previously mentioned, divided into two general classes; namely, those hinged at the sides, and those hinged at the top or bottom. The first named are usually hung in pairs, closing at the center with rabbeted meeting stiles in much the same way as a pair of folding doors, and are called "French casements," from the country of their origin.

Fig. 29 shows the plan (*a*), elevation (*b*), and section (*c*) of a French window, together with the general details of its construction. In the plan (*a*) are seen the double studs *b* forming the sides of the frame opening, over which the sheathing *d* is laid on the outside, and the grounds *g* and lath-and-plaster *i* on the inside. Extending through the opening, from the sheathing to the grounds, are the jambs *a*, the joints of which are covered on the outside by the casing, or blind-hanging stile, *c*, and on the inside by the trim *f*. Between these jambs, the two sashes are hinged and tongued into the jambs as shown at *x*, the corners of the stiles, however, being rounded as shown, to permit them to clear the groove in opening. The sashes are hung with

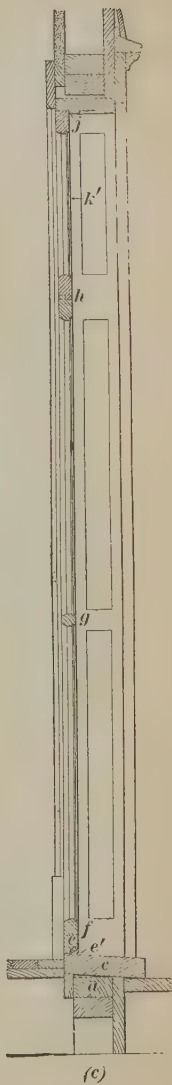
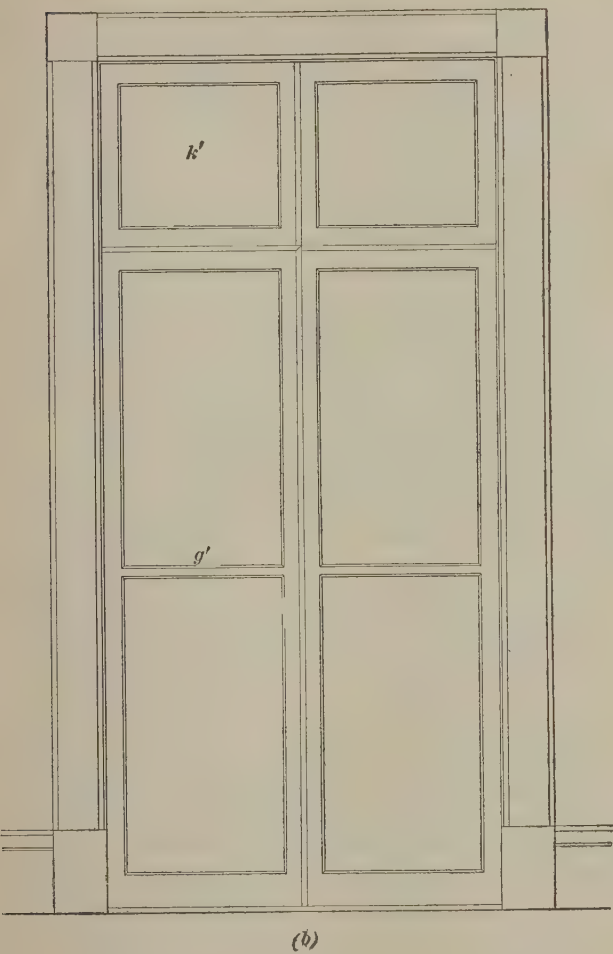
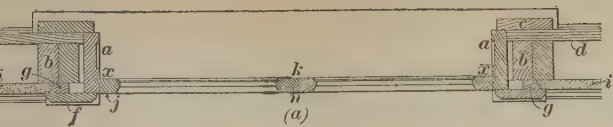


FIG. 29.

small hinges, and the meeting stiles are rabbeted in the same manner as are folding doors, as shown at *kn*, to enable them to make a tight joint when closed.

In the vertical section (*c*), taken through the center of one of these sashes, the rough sill of the stud opening is shown at *a*, while the window sill resting on the veranda floor is shown at *c*. This sill covers the bottom of the opening from the veranda floor to the inside of the lower sash rail *f*. This sash rail is grooved on its under side, as shown at *c*, and the sill is worked with a shoulder, the front of which is also grooved as shown at *e'*, while the top of it is beveled off at the same pitch as the sill. The groove in the front of the shoulder *e'* tends to prevent water from being blown into the crack during a rain storm, and the slanting sill and grooved lower rail permit the moisture to drip off the latter, and run to the outside of the opening.

At *g* is shown the section of the middle bar of the window, which is seen in the elevation at *g'*, and at *h* is shown the top rail of the hinged sash and lower rail of the fixed transom sash *h'* over it. The hinged sash is but 5 feet 6 inches in height, as this is sufficient to permit the window to be used as a means of ingress and egress, while the full opening is 7 feet high.

In the construction of the window head, the framing is precisely the same as at the sides, shown in the plan (*a*), except that the jamb *j* in the top of the window is not grooved as at *x* in the plan (*a*).

64. Windows in Curved Walls.—When the wall in which a window frame is to be built is not straight but curved, as would be the case in a circular tower or semi-circular bay window, it is necessary to make a special form of frame laid out from a templet of the exact curve it is required to fit. And if, in addition to the wall being curved, the head of the window is semicircular or semielliptical, the problem is still further complicated by the necessary geometrical development of the details.

In Fig. 30 is shown the plan of a window opening and its

frame built in the curved wall of a tower. The pulley stiles α, α are set parallel to the axial line nf of the opening, so that the sash may be easily removed and replaced from the inside of the structure, which could not be done if the stiles were set on radial lines from the center of the curve.

The back lining is set parallel to the pulley stile to form a

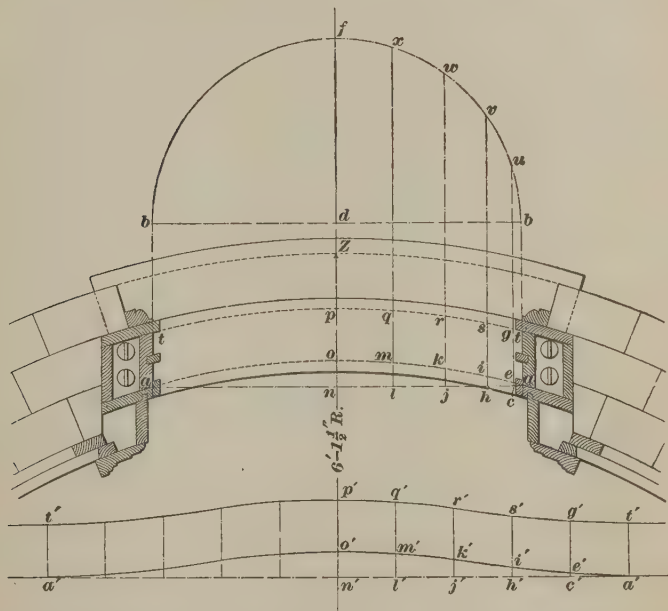


FIG. 30.

proper weight box, and the other details of construction are precisely similar to those described in connection with Fig. 23, except that, owing to the curvature of the sill and head, the details of the framing do not join at right angles, and the semicircular shape of the window head demands special construction.

65. To unfold or develop this semicircular window head, we proceed as follows: Draw a line aa from the inside edges of the pulley stiles, and from each end of it erect the

perpendiculars ab , which will be equivalent to the continuation of the inside faces of the pulley stiles. Above the plan, draw the line bb parallel to aa , and with the point where this line intersects the axial line nf at d as a center,

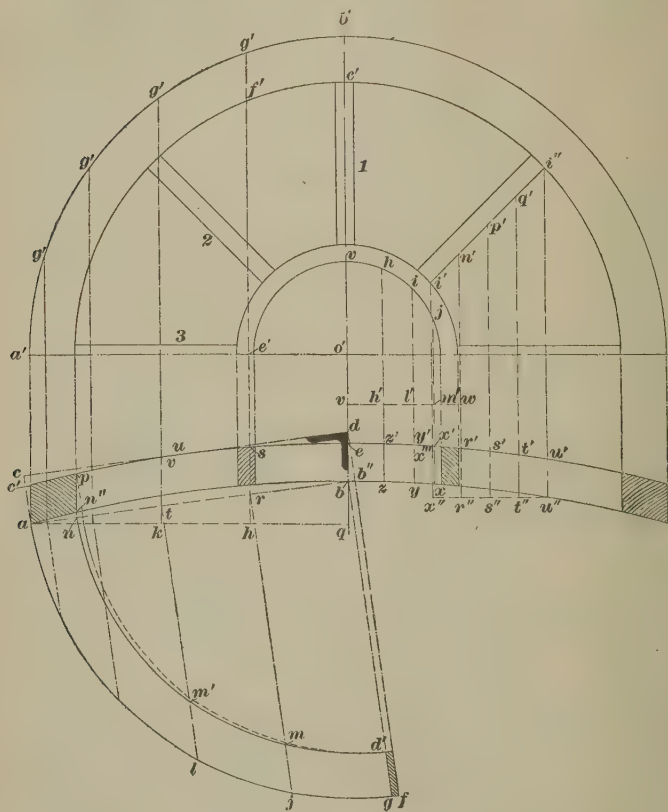


FIG. 31.

and db as a radius, draw the semicircle bfb , which will be the elevation of the inside line of the window head. Now divide one-half of this semicircle bfb into any number of equal parts, by points u, v, w, x , etc., and from these points let fall perpendiculars to aa , as shown at xl, wj, vk , etc.

Somewhere below the plan, the line $a'a'$ is then drawn, parallel to aa , from the center n' of which is laid off in each direction the lengths $n'l'$, $l'j'$, $j'h'$, etc. each equal to the length of the curved lines fx , xw , wv , etc., and, from the points so established, perpendiculars to $a'a'$, as $n'p'$, $l'q'$, $j'r'$, $h's'$, etc., are erected. On these perpendiculars are laid off $n'o'$ and $n'p'$ equal respectively to no and np , $l'm'$ and $l'q'$ equal to lm and lq , $j'k'$ and $j'r'$ equal to jk and jr , etc. These measurements are taken from the plan, where the perpendiculars from the subdivisions of the semicircle bfb intersect the curved lines aoa and $tp t$, shown in the plan of the sill. Curved lines drawn through the points p' , q' , r' , s' , g' , t' and o' , m' , k' , i' , e' , a' will describe the contour of the flat piece required to conform to the shape of the window head when bent around a semicircular form similar to bfb . The method of bending this semicircular head is described in subsequent articles.

66. The construction of a sash whose plan is the segment of a circle, and whose head is a semicircle, is shown in Fig. 31. It is designed to fit the curved window frame just described.

The most satisfactory way of constructing this sash head is to form it of two pieces, each piece being a quarter circle; and, as each of these quarter circles will have a compound curve, it will be necessary to prepare a face mold from which to mark out the curve. To do this, first draw the line ab , Fig. 31, on the concave side of the sash, from the outside edge to the center, and on the convex side draw the line cd parallel to ab and tangent to the sash at u ; also draw ac perpendicular to ab . The rectangle $ab''dc$ then represents the thickness and width of plank required to get out each piece of the top rail. Now divide the curved outside line of the elevation of one-half the window head $a'b'$ into any number of equal parts by points g' , g' , and from each of these points draw lines parallel to the center line $b'e$, intersecting ab at r , t , etc.; and from these points of intersection draw the lines bg , rg , tl , etc., and the line df , all perpendicular

to ab . Lay off on these lines the distances bd' , bg , rm , rj , tm' , tl , etc., equal respectively to $o'c'$, $o'b'$, $e'f'$, $e'g'$, etc., and through the points thus established draw the curves alf and $nm'd'$. Then the curved form $algd'm'n$ will be the face mold which must be applied to and scribed on the stock from which the half-sash head is to be sawed. The shaded portion at gf , shows the waste or surplus, which must be removed in order to permit the two quadrants to meet in a proper butt joint at be . This surplus is removed on the bevel shown at d , which is the angle cdq , formed by the intersection of the tangent line cd with the prolongation of the perpendicular center line $b'b$.

The dotted curved line on the concave side of the face mold shows the amount of extra width required, owing to the fact that the head-piece is sawed squarely through the wood. The plank from which the sash head is to be cut, is first planed on its inside edge to conform with the bevel shown at d . The face mold is then set to the edge of this bevel on both sides of the plank and marked, and the surplus wood is then cut away to the lines as marked. The convex and concave edges of the circular head on the plan lines $ac'eb$ and $n''peb$ will then have the proper shape and angle.

67. Two patterns must now be made which may be applied to the finished convex and concave edges of the circular top rail, in order to mark the convex face line of the sash. To prepare these patterns, first draw a line ab , Fig. 32, on it lay off the distances ad , dg , etc. equal to the divi-

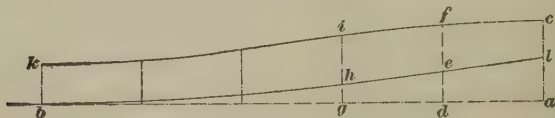


FIG. 32.

sions $a'g'$, $g'g'$, etc. on the convex side of the sash head $a'b'$ in Fig. 31, and from these points erect the perpendiculars ac , df , gi , etc. equal respectively to qe , hs , kv , etc. of Fig. 31. Then through the points c , f , i , etc., draw a curved

line, which will be the line required on the convex face of the sash head. Before applying this pattern to the sash head, it will be necessary to trace another curve $leh b$, which will act as a guide in placing the pattern in position for scribing. To do this, al , de , gh , etc. are laid off equal to qb , hr , kt , etc. of Fig. 31, and the curve $bhel$ is then drawn through the points so located. The pattern $bhlcik$ is then cut out and bent around the convex edge of the rough-sawed window head $abdc$, Fig. 31, in such a position that $bhel$ corresponds with the inside line of the plank, as $atrb$ of Fig. 31. The outside curve $kifc$ is then scribed on the sash head, and will conform to the curve required.

The other pattern is required to trace this same curve on the concave side of the sash head. On the line wk , Fig. 33,

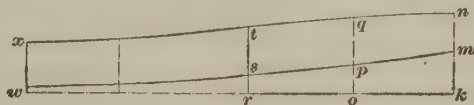


FIG. 33.

are laid off the distances ko , or , etc. equal to $c'f'$, etc., on the concave side of the window head in Fig. 31, and, on the perpendicular lines raised from these points, the distances km , kn , op , oq , rs , rt , etc. are laid off equal respectively to qb , qe , hr , hs , kt , kv , etc. of Fig. 31. The curves traced through the points $nqtx$ and $m p s w$ will then form the pattern for the concave side of the window frame, which must be applied in the same manner as the pattern described in Fig. 32 is applied to the outside, the line $m p s w$ being made to conform to the straight line $n b$ of the concave side of the sash shown in Fig. 31.

These patterns may be cut out of strawboard, or thin sheet zinc, so that they may be readily bent to the curved edges of the top rail. The pattern shown in Fig. 32 is bent around the outside of the top rail, pressed closely and temporarily tacked into place, keeping lc to the joint, and the line $leh b$ to the straight face of the plank marked ab on the plan in Fig. 31, the convex face line $c f i k$ being then marked on the sash head. The pattern shown in Fig. 33 is applied in

and the distances $j'x', j'x, iy', iy, hz', hz$, etc. are laid off on these perpendiculars equal respectively to the distances $m'x', m'x, l'y', l'y, h'z', h'z$, etc., in Fig. 31. Through the points o, z', y', x' , etc. and c, z, y, x , etc., curved lines are drawn giving the proper shape for the front and back edge, respectively, of a plank which is to be bent over a prepared center to form the semicircular arch bar of the sash.

69. The radial bars in this sash head have different curves, according to their position. No. 1 is straight, as it is in the center of the convex surface, and is parallel with the axis of the cylinder, of which the curved front of this window forms a part. No. 3 is curved to the arc of a circle whose radius is the same as that of the window plan, because it is parallel to the base of the cylinder of which the curved front forms a part. No. 2, however, being parallel to neither the axis nor the base, takes a diagonal direction around the surface of the cylinder and, therefore, is curved to the form of a portion of an ellipse.

To lay out the face mold, from which this elliptical curve may be marked on the plank for the radial bar, proceed as follows:

Divide the length of the radial bar in Fig. 31 into any number of equal parts by the points i', n', p', q' , etc., and drop from each division a perpendicular line intersecting the curved plan lines at $r'r'', s's''$, etc. Then, on a horizontal line, as $v'u'$, Fig. 36, lay off the distances $v'u, up, pq$, etc., equal to $i'n', n'p', p'q'$, etc., in Fig. 31, and lay off, on the perpendiculars erected at these points, the distances $v'h, nr, ps$, etc., equal to $x''x''', r''r', s''s'$, in Fig. 31, and through the points h, r, s, t, u , draw a curve which will give the outside line of the face mold required. The inside line of the face mold is then found by drawing a curve through the points h', r', s' , etc., which are located so as to make the distances hh', rr', ss' , etc. equal to the thickness of the sash on the lines $x'''x'', r'r'', s's'', t't''$, etc. of Fig. 31.

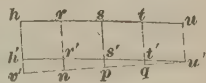


FIG. 36.

SPLAYED WORK.

70. **Splayed work** in joinery is the term applied to cases in which some of the surfaces slope or slant away from, or towards, other surfaces, such as the sides of a pyramid. Such work is frequently encountered in the jambs, sills, or sides of windows or doors, or in the sides of any piece of work placed in an oblique direction to a horizontal or vertical plane.

71. Fig. 37 shows a box, the sides of which *splay* out from the bottom abc , to the top def . To find the angles required in the construction of a square box, or hopper such as is shown

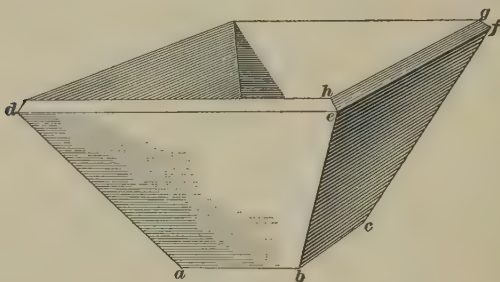


FIG. 37.

in Fig. 37, all four of whose sides splay equally, proceed as follows: Let bc , Fig. 38, be the required splay and position of the sides of a box in relation to the horizontal plane ds , and ab the thickness of the material from which the box is to be made; then $abct$ is the end section of the material, and $xzbaty$ is a vertical section through the box. From c at right angles to ds , draw cj equal to cb ; through j parallel to ds draw ph , and from b draw bh at right angles to ph ; connect hc ; then the angle jhc is the inside face bevel for the sides, and $phcs$ is the size and shape of the inside faces.

72. To find the bevel for a butt joint on the square edge, in Fig. 38, from a , draw af parallel to hj ; from f ,

draw fg at right angles to hj ; make ig equal to the thickness ba ; connect hg ; then jhg is the bevel.

To find the bevel for a miter joint on the square edge—as ghe in Fig. 37—draw ao perpendicular to fa , making vo equal to ba ; connect ho , then jho is the miter bevel.

To find the angle between the two inside faces in a plane at right angles to the face joint ps , draw kl at any point along the line ps , and at right angles to it; at right angles to pl , draw a line from l ; make lm equal to lp ; with m and p as centers, describe the intersecting arcs at q ; connect

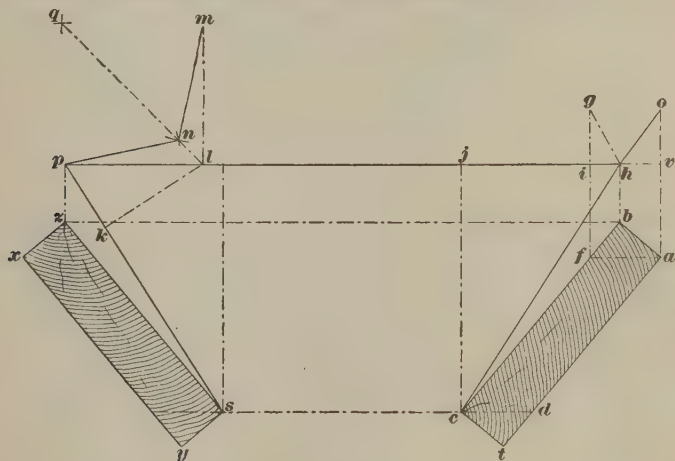


FIG. 38.

ql ; with lk as radius, and on m and p as centers, describe intersecting arcs at n ; connect n to m and to p ; then mnp is the angle sought. Also, the angle pnl is the angle of miter through the thickness holding the stock of the bevel in the direction kl . A block beveled to the angle mnp will fit the angle formed by the connecting faces of the box. If either edge of the box is cut off horizontally, as at cd or fa , then a square line on either of these edges from the face cb will be a butt-joint line through the thickness. An angle of 45° applied from the outside face on either beveled edge cd or fa will be a correct miter through the thickness.

In dovetailing a box like this, instead of squaring across the ends for mortises, use the angle cfa or daf , and, instead of squaring from the ends for the pins, use the angle chj .

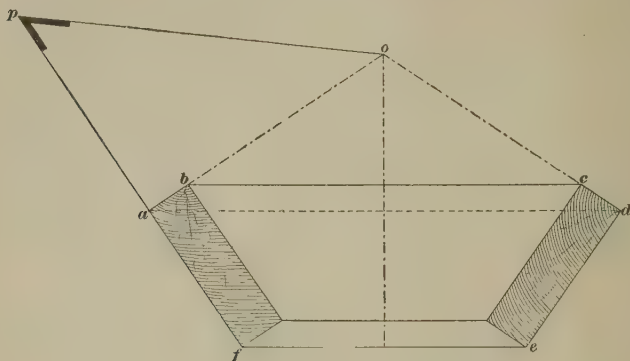


FIG. 38a.

A simple method of finding the miter joint on the square edge is shown in Fig. 38a. The miter joint is the same as the lower face joint of a pyramid formed by the continuation of the edges ab and dc until they intersect at the center o . Let $abcdef$ be a vertical section through the center of the box. Lay off ap perpendicular to ao and equal to half the

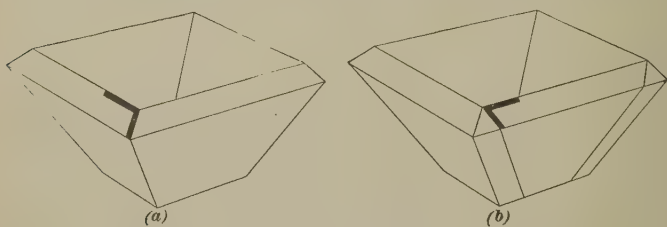


FIG. 38b.

length of the outside edge ad ; connect po , then apo is the required miter bevel to be applied from the outside face.

The application of the miter bevel from the inside edge is shown in Fig. 38b at (a), the bevel for the butt joint, at (b).

To find the angle of the butt joint to apply on the square edge vs : The point s lies in the horizontal plane passing through zp , and this plane is shown on the plan at $lrhfin$; the edge v is represented on the plan by uog . If the edges of the hopper were beveled off to the line ps , the angle for the butt joint would be mid , but since the square edge is to be considered, the joint must be along the line do , because d represents the point s , and o shows the position of v ; then dox is the plan of the butt joint on the square edge. To find the true angle, lay off the distance xc equal to the thickness vs and join c and o ; then xoc is the bevel desired. If either edge is beveled on the line yw or parallel to it, the angle of

the butt joint to apply to that edge is shown at b , while for the miter joint the angle at s would be taken.

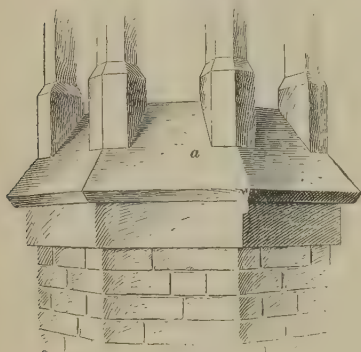


FIG. 39a.

74. Fig. 39a shows the position of an inclined sill a around an octagonal tower. To find the miter for the joint of such an inclined sill at the corners, let $lstvxw$, in Fig. 40, be the plan of the sill at the corner; then zx will

be the plan of the miter line of the sill. Now draw lc at right angles to lz , and let wj be the height, jl the pitch, and lp the thickness of the sill. To find the miter angle down the face of the sill, make lc equal to lj , and parallel to zl , draw cy indefinitely; then parallel to lc draw xy , cutting cy in y , and connect y and z . The bevel at y then indicates the miter angle across the face of the sill.

To find the miter angle on the square edge lp , as at x , Fig. 39a, prolong the plan miter xz toward o indefinitely, and parallel to lz draw po . Draw oc at right angles to lz , and prolong it indefinitely; make rs equal to lp , draw sc

parallel to lz , and connect cz ; the bevel at c will be the angle sought. If the bottom of the sill is horizontal, then lzx will be the angle of miter on that face.

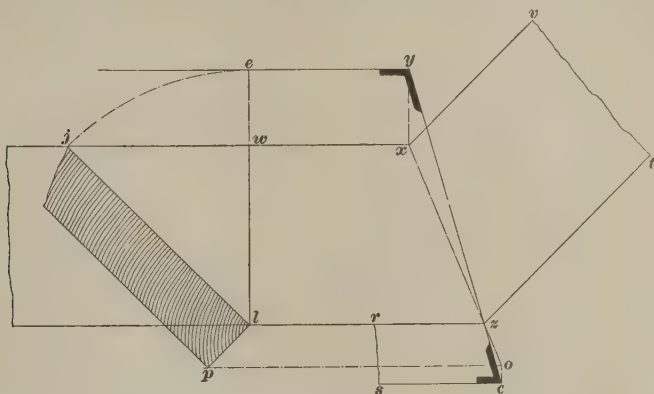


FIG. 40.

75. Fig. 41 shows the method of finding the bevels for mitering the angles of pyramids. Let $abcdefgh$ be the base of an octagonal pyramid, and ijk its elevation; $nopqrst$ is the exact size and shape of a section through the pyramid on the line lm , representing a plane perpendicular to the face jk . To obtain the bevel for the miter joint, lay off mw equal to half the length of yz , projected horizontally from m ; connect w and x , then xwm is the bevel desired. Its application is shown in (b) at q . The method is the same for a square pyramid: Lay off mv equal to half the length of $m2$; connect xv , and the angle at v is the miter bevel for the square pyramid, holding the stock of the bevel at right angles to the edge jk .

76. Window or door openings in straight walls with splayed jambs and circular splayed soffits present problems requiring an accurate knowledge of the treatment of splayed work, to secure the proper bevels and joints. To unfold the length and shape of such a window soffit on the plan of the

Parallel to qf draw pg and $p'g'$; with r' as a center, describe the arcs gf and rx and divide them into any number of equal parts—as gf into five parts, and rx into seven. Draw

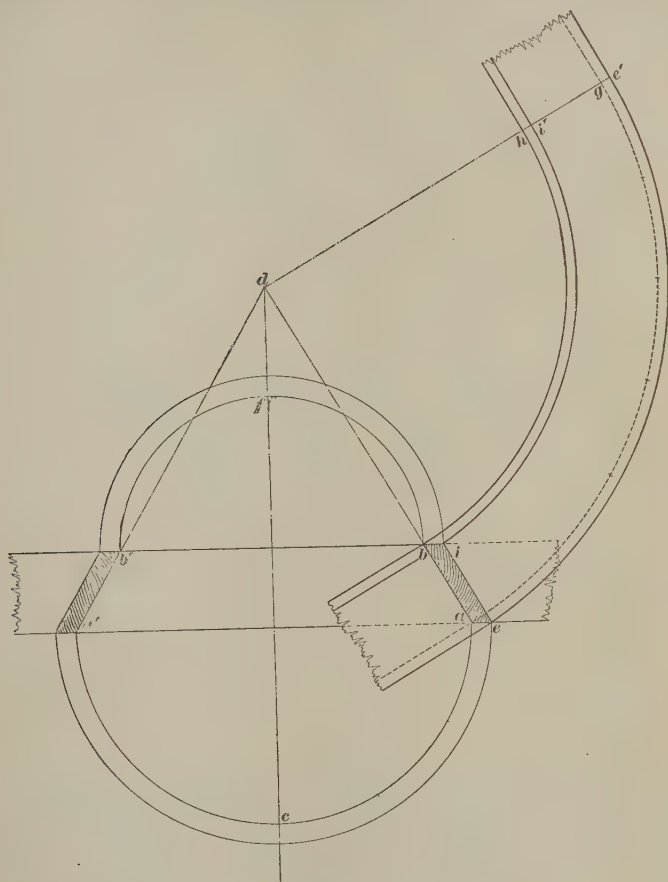


FIG. 42.

$r'y$ parallel to xq , and prolong rp to y . On y as a center, describe the arcs ss , rt , oo' , and ps' ; on the curve from p to s' , set off the five divisions of the line gf ; on rt , set off

draw ha and ha' ; draw aa' at right angles to $g'h$, and tangent to the outer curve of the wall at g' ; tb and $t'b'$ are then the faces of the jambs. From g' as a center, describe the semicircle $a'fa$; divide the quarter circle fa into three or more equal parts, as at d and d' . From these points draw

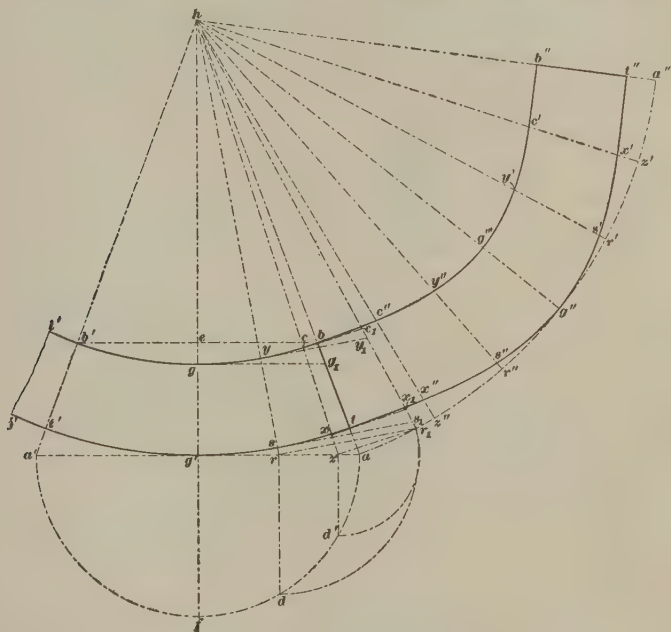


FIG. 44.

perpendiculars to $a'a$, as dr and $d'z$, and draw rh and zh . With h as a center, describe the arc aa'' of indefinite length; on it, twice set off the number of divisions of af , as as'' , $z''r''$, etc.; from these points, draw lines to h . Next project g to g_1 , and g' to a ; then g_1a is the true length of gg' . On hg'' in the development, which represents hg' in the plan, lay off, from g'' , $g''g'''$ equal to ag_1 . Again, from r , draw rr_1 perpendicular to hr , and equal in length to rd , since the true position of r is vertically above r on the plan a distance equal

to rd . Draw hr_1 ; also draw ss_1 and yy_1 perpendicular to hr until they intersect hr_1 ; then y_1s_1 is the true length of ys . Mark it on the corresponding lines hr'' and hr' in the development, by making $r''s''$ and $r's'$ equal to r_1s_1 ; and $s''y''$ and $s'y'$ equal to s_1y_1 . Similarly, to find the true length of cx , draw sr_1 perpendicular to hz and equal to zd' . In this case, the measuring line coincides with the first one, hr_1 . Now draw xx_1 and cc_1 perpendicular to hz until they intersect hr_1 .

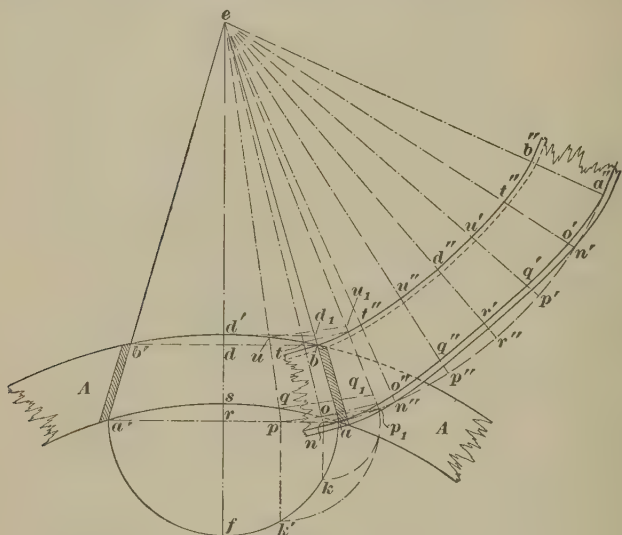


FIG. 45.

Then c_1x_1 shows the true length of cx . It is laid off on the development lines by making $s''x''c''$ and $s'x'c'$ equal to $r_1x_1c_1$. As at and tb are shown in their true length on the plan, $a''t''$ and $t''b''$ are laid off on ha'' equal to the corresponding lengths on ha . Through all the points thus found, draw the outlines, and the figure $tbg'''b''t''g''$ will be the required development of the soffit. From tb and $t''b''$ the straight jambs will be spliced to the length required, a splicing portion to be left on at both sides.

79. The plan of a window or door opening in a circular wall where the jambs and circular soffit splay equally, is shown in Fig. 45. Let A be the circular wall, and ab and $a'b'$ the splayed jambs of the opening. Draw $a'a$ equal to the width of the opening on the concave side of the wall, and $b'b$ equal to the width of the opening on the convex side of the wall. Continue the sides of the jambs ab and $a'b'$ till they intersect at c . Draw cf at right angles to $a'a$; with r as a center, describe the semicircle $a'fa$. Divide the quarter circle af into three or more equal parts, as at k and k' ; from these points draw kn and $k'p$, perpendicular to $a'a$; also, draw ep and en . With e as a center and ea as radius, draw the arc aa'' of indefinite length, and lay off from a on it the distances an'' , $n''p''$, etc., equal to ak , kk' , etc., the number of divisions being twice those laid off on af ; draw lines from e to n'' , p'' , etc. To find any developed length, uqp , for example, draw pp_1 perpendicular to ep , and equal in length to pk' ; also draw ep_1 . Draw uu_1 , and qq_1 , parallel to pp_1 ; then p_1q_1 and q_1u_1 are the true lengths of p_1q_1 and q_1u_1 , and, laid off as shown on the proper lines, corresponding to ep , as ep' and ep'' , will give points on the development of the soffit. All other points being found in the same manner, the complete development is $bd''b''a''r'a$. The outer full line and the dotted line represent the beveled edges of the soffit.

80. The plan of a window or door opening in a straight wall with splayed jambs, and a semicircular soffit on one side of the wall, and a semielliptical one on the other side, so arranged as to preserve the crown of the soffit level, is shown in Fig. 46. Let A be the wall, and aa' , oo' the opening and splay of the jambs; continue the splayed-face line of the jambs $a'o'$ and ao to f ; through the center of the opening, draw the center line fj ; from k as center, and with a radius ko' , draw the semicircle $o'uo$, which will be the interior elevation of the window head, and divide it into any number of equal parts—in this case six; through each of these parts, as r , t , etc., let fall a perpendicular to $o'o$, as

rc, td , etc. From f , through c and d , draw fz' and fv , and repeat the construction on the other side of the center; at right angles to aa' draw $z'n', vn, lj$, etc.; make $z'n', vn, lj$, equal to cr, dt, ku , etc., respectively. Through the points found draw the semiellipse $an'nja'$, which will be the outline of the exterior of the opening. To find the length and shape of the soffit, draw fb at right angles to fa ; make fx, fy , and fb equal to cr, dt , and ku , respectively; with

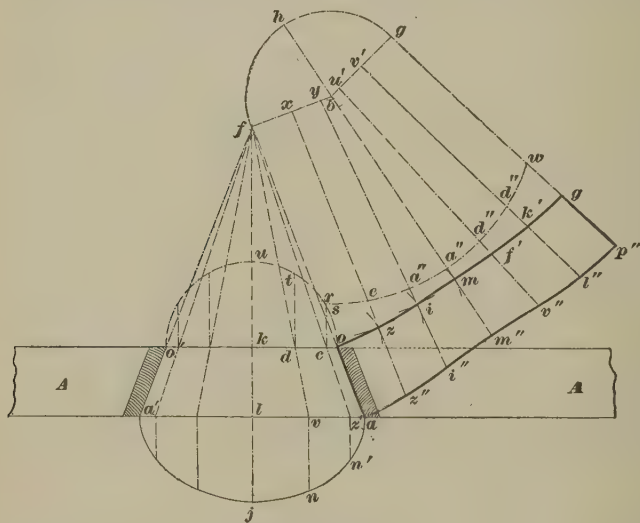


FIG. 46.

fc as a radius, and with x as a center, describe an arc at z ; then, with os as a radius, and with o as center, describe another arc at z intersecting the first one. Through z draw the line xzs'' indefinitely; with fd as a radius, and y as center, describe an arc, and with st as a radius, and z as center, describe a second arc intersecting the first at i ; from y draw through i the indefinite line yi'' . Next, with fk as a radius, and b as a center, describe an arc, and with tu as a radius, and i as a center, describe a second arc intersecting

the first at m ; through m then draw the line bmm'' indefinitely. With b as a center and bfa as a radius, describe an arc fhg . Prolong mb to h ; make the arc hg equal to the arc hf and connect bg ; make $bu'v'$ equal to bys . With b as a center, with any convenient radius, describe a measuring arc rw ; from a'' , where the line hm'' intersects this arc, lay off the spaces $a''d''$, $d''d'''$, and $d'''w$ equal to $a''a'$, $a''c$, and cr on the opposite side; through w draw gwp'' , and then through these points draw $v'l''$, $u'v''$, etc. Make ss''

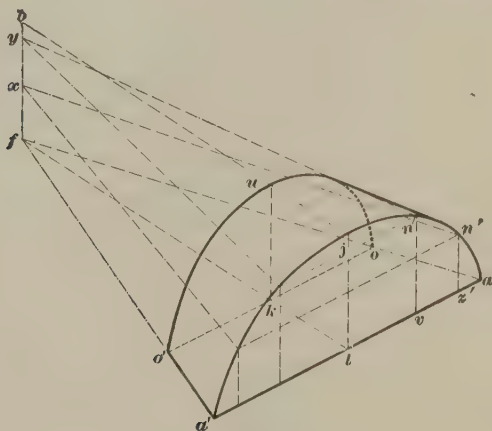


FIG. 47.

equal to cs' , ii'' equal to dv , and mm'' equal to kl , etc.; make wg and wp'' equal respectively to ro and ra , $d''k'$ and $d''l''$ equal respectively to es and es'' , and $d''f'$ and $d''v''$ equal respectively to $a''i$ and $a''i''$; a curve through $ozimf'k'g$ is the interior edge of the soffit; and one through $az''i''m''v''l''p''$ is the exterior edge. Sufficient overwood must be allowed beyond gp'' and oa to bevel the edges of the soffit to attach to the straight jambs, $p''g$ and ao , which are spliced on as required.

To insure a better understanding of this work, a perspective drawing of the conelike solid, the surface of which

corresponds to the contour of the inside of this arched opening, is shown in Fig. 47. At the interior, the opening is circular, as shown at $o'u o$, and, the top uj being level, the height jl on the exterior is the same as the height ku on the

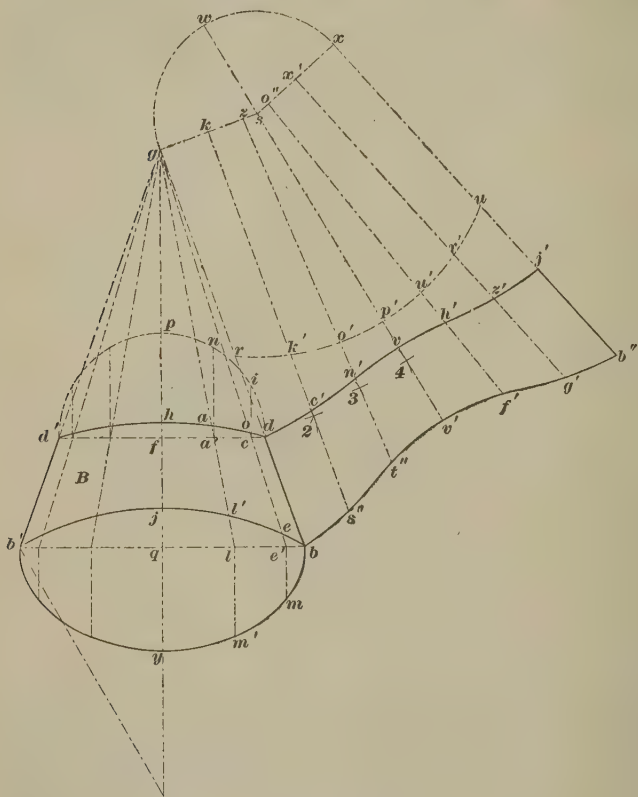


FIG. 48.

interior; but the sides of the opening splay toward the outside, and the width on the exterior $a'a$ is greater than the width on the inside $o'o$, so that the exterior elevation of the opening $a'ja$ is elliptical. The other letters in Fig. 47 refer to the same points as similar letters in Fig. 46.

81. A plan of a window or door opening in a concave circular wall, with the jambs splayed, the soffit a semicircle on one side of the wall, and the other side a semiellipse, the crown of the soffit being level, is shown in Fig. 48. Let B be the circular wall, and bd and $b'd'$ the splay of the jambs; continue the splayed face of jambs $b'd'$ and bd to g ; from g through the center of opening draw the center line gy indefinitely; from f , the intersection of this center line with the line dd' , describe the semicircle $d'pd$, and divide it into any number of equal parts, through each of which, as i , n , etc., let fall perpendiculars, ic , na' , etc., to dd' ; from g draw lines through c and a' to e' and l ; perpendicular to $b'b$ draw $e'm$ and lm' equal respectively to ci and $a'n$; make qy equal to fp , and then trace the exterior semiellipse $bmm'yb'$.

To find the length and shape of soffit, draw gs at right angles to bg ; make gk , gz , etc. equal to ci , $a'n$, etc., and with s as a center, describe the arc gwx of indefinite length. With gc as a radius, and k as a center, describe an arc, and with di as a radius, and d as a center, describe a second arc cutting the first at 2 ; through 2 draw ks'' . Next with ga' as a radius, and z as a center, describe an arc, and with in as a radius, and 2 as a center, describe a second arc intersecting the first at 3 ; with gf as a radius, and s as a center, describe an arc at 4 ; with np as a radius, and 3 as a center, describe an intersecting arc at 4 , and through s and 4 draw sv' indefinitely. Lay off $4v$ equal to fh , also $3n'$ and $2c'$ equal respectively to $a'a$ and co . Make $c's''$, $n't''$, and vv' equal to oc , al' , and hj , respectively. Make wx equal to wg ; connect sx ; make $so''x'$ equal to szk ; from s as a center, with any convenient radius, describe a measuring arc $rp'u$, make $pu'r'u$ equal to $p'o'k'r$; through u draw xb'' . Lay off uj' , ub'' , $r'z'$, $r'g'$, $u'h'$, and $u'f'$ equal respectively to rd , rb , $k'c'$, $k's''$, $o'n'$, and $o't''$; through the points d , c' , n' , v , h' , z' , j' trace a curve, which will be the convex edge of the soffit; and through the points b , s'' , t'' , v' , f' , g' , b'' trace a second curve, which will be the concave edge.

83. To miter a straight and circular molding, the straight molding to be tangent to the circular one: Let $oo'tt'$, in Fig. 51, be the circular molding, and x a cross-section of it; let $ss'rr'$ be a straight molding, with the same cross-section

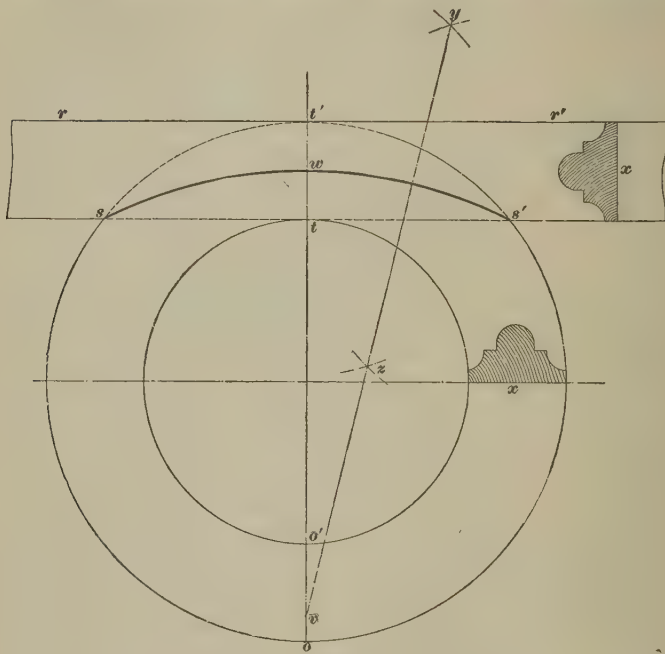


FIG. 51.

x . Bisect tt' at w ; with s' and w as centers and equal radii, describe intersecting arcs at y and z ; join y and z and produce the line to intersect $oo'tt'$ in v . Now from v as a center, describe the arc sws' , which will be the miter line required.

84. To miter a straight and circular molding intersecting at an acute angle: Let $ba'a'c$, Fig. 52, be the straight molding, and aa' the cross-section; $zz'cb$ the circular molding, and zz' its cross-section; through the straight and circular moldings draw the center lines ts and os respectively. With c and s as centers and equal radii, describe intersecting arcs

as r and l , and through r and l , draw the line ry of indefinite length. With s and b as centers and a convenient radius, describe intersecting arcs as j and x , and through these points

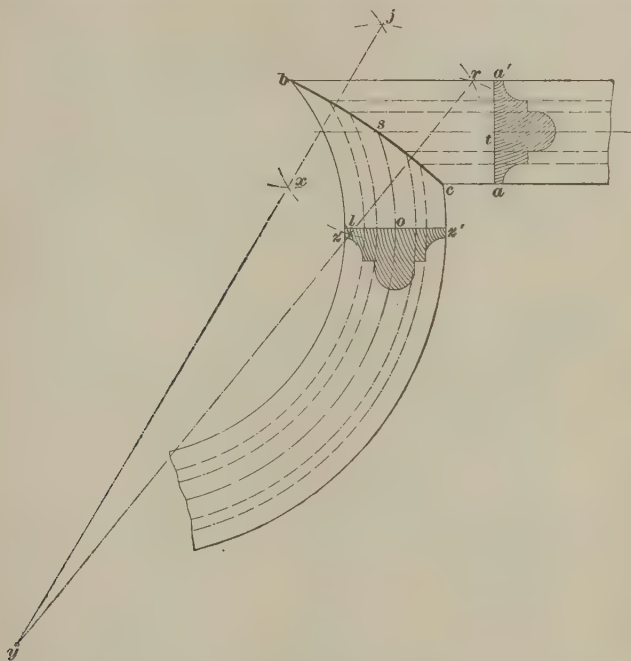


FIG. 52.

draw the line jy , cutting the line rl in the point y ; with y as a center, describe the curve bsc , which will be the miter line required. These miter lines on circular moldings are called *hunting miters*.

BENDING WOOD.

85. When it is required that a surface shall present a curved form, the wood may be bent around it by any one of five methods, namely, by **saw kerfing**, **keying**, **backing a veneer**, **laminating**, or **steaming**.

86. Saw kerfing, being less costly than other methods, is often adopted. The method is not to be recommended, however; it makes a weak construction, and no matter how perfectly the work may be done, or how well it may be painted, the saw-kerf marks will always show. For hard-wood moldings the method should never even be considered, and for curved work of whatever kind, solid molding should always be used.

A center, built to the desired diameter or curve, over which the material may be bent, and which will stay permanently and accurately in its curved form, is absolutely necessary with any of the above methods. In Fig. 53, the rib

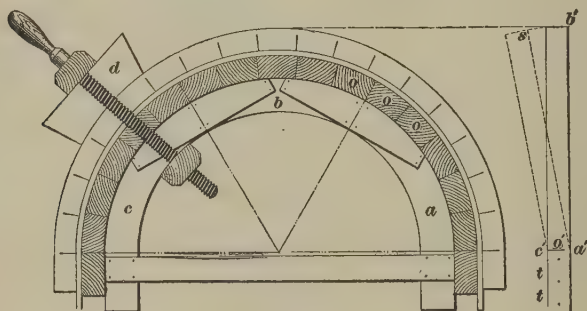


FIG. 53.

abc for a center is composed of three pieces of $1\frac{1}{4}$ -inch plank; it is made concave on its inner edge, merely because it is sometimes an advantage (when it can be done) to clutch the bent stuff and the rib with hand screws as shown. Blocks, as shown at *d*, extend the power of hand screws considerably beyond the width of the jaws, and are therefore exceedingly useful. The staves of wood *o, o, o*, etc., of any length required, are nailed to the rib *abc*, and form the circular surface of the center. To find the distance between saw kerfs that will allow the material to bend to the curve required, take a piece of stuff of a suitable length and equal to the thickness of that which is to be bent, as at *c'a'*, and let *a'b'* be equal to the radius of the curve to which it

is to be bent; make a saw kerf at $c'o'$, leaving a thickness $o'a'$ from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch uncut; nail the piece at t, t ; and move it from b' to s , or enough to just close the saw kerf at c' ; then $b's$ will be the given distance between two saw kerfs. The distance $a'o'$ to be uncut must be gauged along each edge of the stuff to be bent, and the same saw must be used with which the cut $c'o'$ was made. In this method of bending, a thin veneer is first laid, and the saw-kerfed piece is then bent over it and glued to the veneer. This is the better method of treatment in saw kerfing, but the saw kerfs may also be cut in the convex face of the stock, and when bent over the center, the veneer may be glued over the convex surface to secure it.

87. Keying.—Fig. 54 shows another method of treating material which is required to be bent. In this method grooves are made in the back of the stuff at suitable inter-

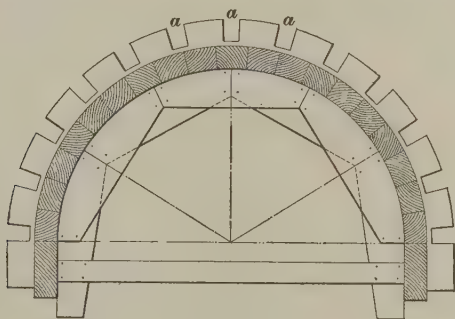


FIG. 54.

vals (found as directed for space between saw kerfs) of an even depth, as shown at a , leaving an interior thickness of $\frac{1}{8}$ inch or $\frac{1}{4}$ inch, depending on the radius of curvature. These grooves are filled with well fitted wood strips called *keys*, plenty of glue having first been brushed in the grooves and over the keys. Two strips of veneer 3 inches to 4 inches wide, glued and nailed over the convex face of the bent piece near each edge, tend to strengthen the work materially.

The ribs of the center shown in Fig. 54 are in four parts, with bracing pieces nailed over each joint as shown.

88. Bending by **backing a veneer** is the third method, shown in Fig. 55. Enough wood is planed from the back of the stuff to be bent, to leave a veneer of the proper thickness and length between rr , the circumference of the semi-circle; then, when bent over the center, the thickness is filled

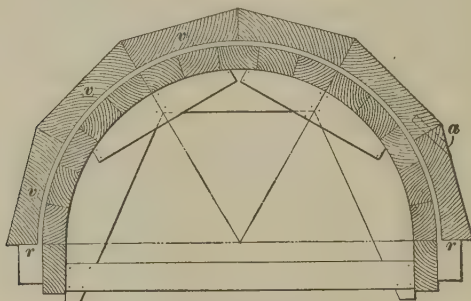


FIG. 55.

out as required by fitting and gluing on the back of the veneer the cylindrical-faced staves v, v, v , etc. These staves are made a little long, and each one, after being fitted and glued, has a long screw driven through its thickness to the center, near each end, to hold it down and keep it in place until all are fitted and glued. To increase the strength of this curved piece of work, before taking it off the center, the joints may be united by hardwood dowels, glued and driven in as shown at a .

89. Laminated Curved Work.—The fourth method, as shown in Fig. 56, is a mode of bending and gluing together several layers, as shown at a , to make up the required thickness. These should all be fixed and glued over the center at one operation, and, if possible, left there some days to dry out. This is by far the strongest and best method of all for most purposes; but it will not do for moldings, as the

edges in hard wood, when cut into, show the streaks of glue,

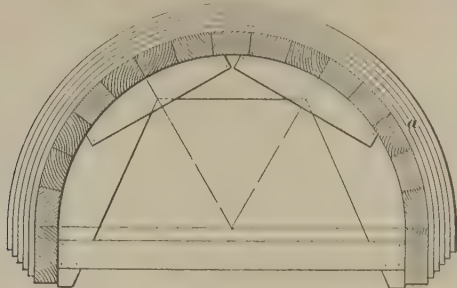


FIG. 56.

this, however, would be unobjectionable where the work is to be painted.

90. The fifth mode of bending is by **steaming**. Some woods bend easily when steamed, but all must be handled with rapidity after steaming, allowing no time for cooling until after the work is secured to the center. A good steam box of suitable size must be prepared and wet steam must be used, since dry, superheated steam makes wood brittle but not flexible.

To find the thickness of white pine (without preparation) that may be bent without injuring its elasticity, *multiply the radius in feet of the curvature required, by the decimal .05, and the product will be the thickness in inches.* For example, take a 5-foot radius; multiplying this by the given decimal, the thickness that will bend without fracture is $5 \times .05 = .25 \text{ inch} = \frac{1}{4} \text{ inch}$.

VENERING.

91. Hard woods, such as oak, ash, rosewood, etc., cannot be used in joiners' work, where the pieces are of any considerable dimensions, unless they are backed up with some lighter or more reliable wood which is less affected by moisture or change of temperature. The hard wood is, therefore,

usually cut in thin slabs and glued to a piece of pine or other soft wood, in such a manner that the finished work has the appearance of a solid block; while in reality its interior or core is of an entirely different material. This process is called *veneering* and the thin slabs of hard wood are called *veneers*. It is a mistake to suppose that veneering is resorted to as a matter of economy, to save the enhanced cost of solid wood. Hard woods are liable to warp or twist out of proper shape. Especially is this the case with doors built of solid hard wood; and so it becomes absolutely necessary, in order to make a good door and secure the decorative elegance in color and grain of the hard woods, to employ veneering in door making; this, properly done with good glue, will last as long as the wood upon which the veneer is laid.

It is not good practice to use two kinds of wood in veneering a door; as one face mahogany, the other oak; or maple and cherry; oak and black walnut, etc. The varying conditions of the atmosphere, heat, and moisture act differently upon the two kinds of wood, and the doors have a tendency to warp. This is equally the case with a door where one face is in a warm room and the other face constantly exposed to different atmospheric conditions, even though both sides of the door are veneered alike. If only one side of a panel is veneered, it will curl badly when dry; consequently all veneering should include both sides.

The choicest and most beautiful veneers are cut from the crotches, and also with some woods from the roots of the trees, where the grain is gnarled, mottled, and attractively intermingled. These choice veneers are used on the surfaces of panels, and are highly polished to bring out the beautiful, natural changes and color qualities peculiar to the wood; this is relieved by the less-polished plain surface of the framework. The frame, or stiles and rails, is invariably veneered with plain straight-grained veneers finished flat.

92. There are several valuable accessories to good veneering which must not be overlooked. The first of these is a good heating box, of a length and width sufficient for long

and short materials. Such a box may be cheaply constructed of plank, and lined with tin, with its cover or lid in three sections; the box should be piped and heated by steam, or in the absence of steam it may be heated conveniently by a 6-inch stovepipe carried through it lengthwise. In all cases heated cauls are used against veneer to keep the glue hot, so that the wood may the better absorb it. The caul also distributes the pressure of the hand screws on the whole surface of the veneers evenly, during the several hours required for the glue to set. A *caul* is a piece of wood or other suitable material curved or straight, as the case may be, to fit the surface to be veneered. When used for door stiles or panels, a thickness of 1 inch will be sufficient, and its width and length should never be less than that of the material to be veneered. To prevent the caul from sticking to the veneer, it should be coated with beeswax or paraffin; or, in the absence of these substances, brown paper cut to size will serve the purpose if laid between the veneer and caul; brown soap is sometimes used, but frequently stains the wood.

93. In door making, the core should be clear white pine; the stiles are built up of several strips, the grain of each reversed with reference to that of the adjacent piece, and all glued together. The edges of the stile have hard wood glued on as required; the stile is then faced straight out of wind, and is well scratched lengthwise by means of a toothed plane; and the veneer should also be scratched. The glue should be well cooked—if burned it is useless—of a good body, not too thick, and plenty of it should be brushed on the surfaces which are to be in contact, as the wood absorbs considerable of it. In Fig. 57, at (*a*), is shown a section through a door stile such as described; the caul is seen at *a* against the veneer *b*, while the core is shown at *c*. Several stiles or rails may be veneered at one time with only outside cauls, but with paper between the veneers. The veneers require to be tacked in two or three places to keep them in position until clamped together with hand screws, which should be spaced

not more than 6 inches apart—in fact they can hardly be put too close together. The hand screws are placed

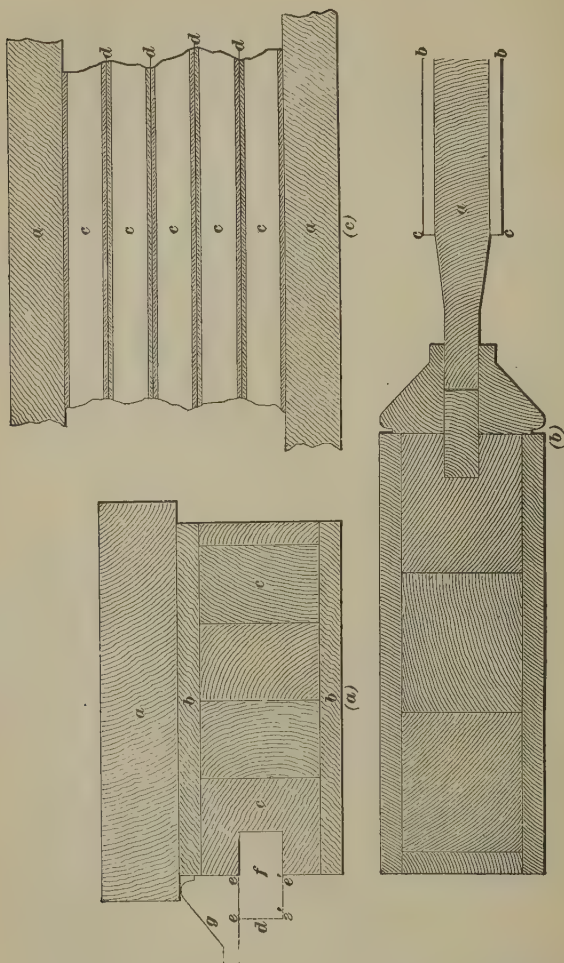


FIG. 57.

at opposite sides alternately, to insure an even pressure on both edges, which drives the glue into the pores of the

wood. In paneled work, where hard-wood moldings are used, it is desirable to avoid the use of nails to secure the moldings in place.

At *f*, Fig. 57, is shown a pine strip glued into the groove of the door stile, against which the panel moldings *g* are mitered and glued at *e e*; then the polished panels are set in place at *d*, and the other face of the door is molded and glued to *e' e'*. Another example of door-stile molding and panel is shown at (*b*); the panel *a* is usually made of the same kind of wood as the veneer, but plain; sometimes, however, the raised face *b c* is veneered with choice wood of finely marked grain, polished and finished before it is placed in the door. All plain-faced material may be clamped and veneered together in quantities, as shown in Fig. 57 (*c*). The core pieces *c, c* are separated by layers of paper between the veneer faces, as seen at *d*, one operation with the hand screws and two cauls *a, a* sufficing to secure the whole.

94. Thin veneers are often found in a badly crumpled condition. In this case, they must be sponged with hot water and squeezed gradually and evenly with hand screws between plane-surfaced cauls, and left several hours or over night, until they are in a fit condition to be laid. Sometimes heavy weights placed on a caul over the moistened veneers are sufficient to accomplish the same effect.

95. In order to join two pieces of thin veneer, they must be cut with a sharp knife, guided by a perfect straight-edge. The pieces are laid upon a plane surface with paper underneath, and are tacked at a convenient distance on each side of the joint in such a way as to draw the two pieces together; then a strip of strong Manila paper is glued over the joint, and the veneer is placed on a suitable straight strip of wood under heavy pressure and allowed to remain until the glue is dry. In laying this jointed veneer, the papered side must be laid outwards.

96. The veneering of a small circular column may be accomplished as shown at Fig. 58. Here a sheet of tin is used, having cleats securely nailed to each end by which hand screws can be made to press the heated tin caul and veneer tightly to the surface of the column. The tin should be about $\frac{3}{4}$ inch shorter than the circumference of the column, in order to leave room for the glue that is squeezed out along the

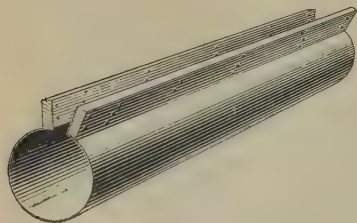


FIG. 58.

joint. The veneer should be sponged with hot water just before straining it around the column. The column and the tin should be heated before veneering. The advantage of a tin caul is that it requires no waxing, and will not stretch. A strip of paper wrapped around the core will be sufficient to determine the length of the veneer, which must be equal to the circumference of the column. To bring the two edges of the veneer together when the tin caul is removed, long solid cauls are used, as shown at *s* in Fig. 59.

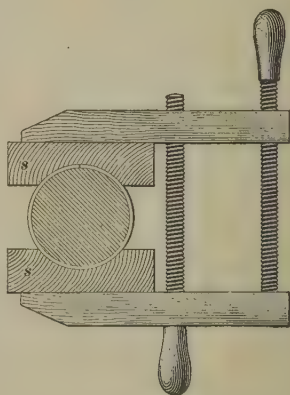
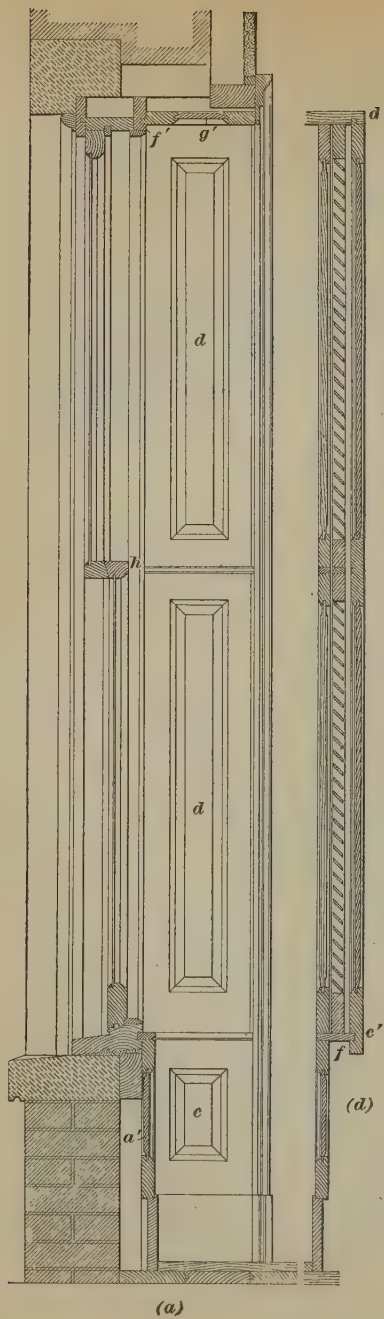
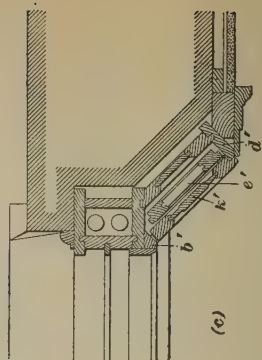


FIG. 59.

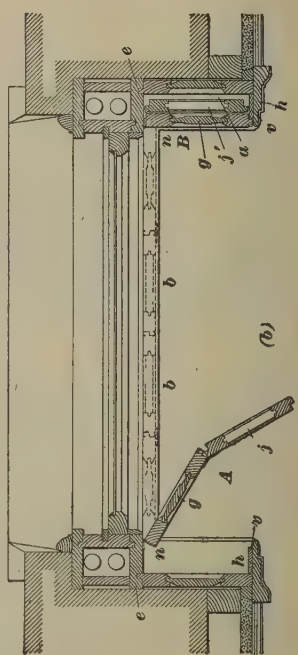
97. A tapering column is veneered in precisely the same manner, but to find the length and shape of the veneer, lay out, as in Fig. 60, *ab* equal to the height of the column and *cd* the diameter of base; continue *ce* and *de* to *i*; from *i* as a center, with *ic* and *ie* as radii, describe the arcs *ch* and *ef*; from *a* as a center, describe the semicircle of the base *cd*; divide the semicircle into any number of equal parts, and mark these parts twice on the unfolded base line



(a)



(c)



(b)

FIG. 61.

in all cases. Inside blinds are usually made of hard wood to match the trimming of the room containing them, while outside blinds are nearly always framed of pine and painted to protect them from the elements. Outside blinds must also be constructed with consideration of the fact that they are likely to be subjected to rather rough usage through the influence of high winds and rapid changes of temperature.

99. Inside folding blinds make a very neat, as well as a most useful fitting for the inside of a window, and they should be so arranged that, when closed into their box, the exposed blind will show a panel finish on the inside of the room, as shown at *d*, Fig. 61 (*a*). These shutters are usually built in a square jamb, as shown in the plan, Fig. 61 (*b*), though, when circumstances will permit, they may be built in a splayed opening, such as is shown in Fig. 61 (*c*), in which case the panel work shows up to better advantage, and the room is rendered lighter.

In Fig. 61 (*b*) the full plan of the window is shown with the shutters closed into the box at *a*, while the dotted lines at *b* indicate the position of the shutters when opened out of the box and closed over the window sash. The extreme width of the shutters between the outside hanging stiles *n* is $1\frac{1}{2}$ inches more than the width of the window between the pulley stiles, and is divided into four parts, each one of which represents the width of a leaf, or wing of the inside blinds. Two of these leaves are usually paneled, as shown at *g*, and the other two are provided with fixed or movable slats, as shown at *j*. The slatted portion is hinged to and folds behind the panel, as at *A*, and the two then revolve on hinges connecting the paneled leaf to the casing and close into the box with the panel on the exterior as shown at *B*.

These blinds are framed together in one piece, from the inside sill to the window head, in the same manner as the rails and stiles of a door, except that the outer leaf *j* of the blinds is filled with fixed or movable slats or louvers, instead of paneling, as is the inside leaf as seen at *d*, Fig. 61 (*a*).

The space between the sill of the window and the floor is

usually covered by a *panel back* shown in section at *a'*, Fig. 61 (*a*), and its return under the blind box is shown at *c*. This panel back is usually paneled similarly to the blinds above, and is constructed in the same manner as the paneled shutters.

At (*d*), Fig. 61, is shown a section through the panel back and blind box; at *f* is seen the bottom of the box, housed into the lining *c'*, which forms the back of the inside of the blind box and is secured at the top by a tongued-and-grooved joint into the soffit piece *d*. This soffit piece *d* is paneled to match the blinds and panel back in the jambs, as shown at *g'*, Fig. 61 (*a*), and is secured by a tongue worked on its edge and let into the window casing at *f'*. The inside lining *e* of the weight box, Fig. 61 (*b*), in the window frame, forms the outer lining of the shutter box, and the inner lining of the latter, as shown at *h*, is attached to and forms a part of the interior trim. The paneled blinds *g* are hinged to the hanging stile as shown at *n*, while the slatted blinds *j* are hinged to *g*, so that the knuckle of the hinge is entirely within the edge of the stile of *g*. This method of hanging permits the blind *j* to swing back sufficiently from the edge of the stile to secure it against any danger of catching on or against the edge of the architrave, or the blind stop *v*, when the blind is closed into the box as shown at *B*. This is still further accomplished by making the blind *j* $\frac{3}{4}$ inch narrower than *g*, so that there will be no tendency for it to become jammed in the box. The rabbeted joint between the two blind flaps *g* and *j* is only $\frac{3}{8}$ inch deep, and is provided simply to secure a light-tight joint.

100. When the jambs of the window are splayed, as shown in Fig. 61 (*c*), there is but a slight difference in the construction of the blinds themselves, though the box requires a little extra attention. At the outside edge of the box, on the side next to the window, the extra hanging stile *b'* is introduced, to provide at the front edge of the box a proper depth for the paneled shutter *k'* to shut into, as without it the blind would close back no further than in the square jamb shown in Fig. 61 (*b*). The box jamb *d'* is also necessary at

the inner side of the box, to form a satisfactory stop for the blinds, and to make a neat finish to the box itself. In splayed window jambs, the blind c' , which folds inside, must be made from $1\frac{1}{2}$ to 2 inches narrower than the exterior blind k' .

101. When inside blinds are required for a window, it is first necessary to lay out a measuring rod with the stiles, rails, and panels marked as described for the framing of doors, etc. The entire blind, from the sill to the window head, is laid out and constructed in one piece, and then sawed apart at the center of the meeting rails, as shown at h in Fig. 61 (a). The shutters are temporarily hinged and hung in place, so as to insure their proper fit, and the marks are then made at the meeting rails, to which the blinds are afterwards sawed, thus forming a separate set of shutters to cover the upper and lower sashes independently.

102. Outside blinds differ from inside blinds only in such details of construction as their more exposed situation requires. Fig. 62 shows at (a) the inside elevation of an outside blind, and at (b) is shown its plan. The hanging stile for the blind on the window frame is shown at c , and the form of hinge necessary to permit the blind to open around the angle of the brickwork is shown at b . The shape of this hinge and its attachment to the shutter is shown by the dotted lines at f . The angle in the hinges permits them to extend over the joints at the top and bottom rails, and adds strength to the shutter, besides rendering it more secure in high wind storms than would the ordinary hinge.

The extreme length of the arm ob , carrying the pin half of the hinge, permits the shutter to swing around the outside of the brick wall clear of the opening, as shown by the dotted lines, but the corresponding length od causes the blind when opened to move first in the direction da , and is likely to cause the shutters to bind when they are opened. This tendency, however, is compensated by the thinness of the metal of which the hinges are made, as they can be easily *sprung* out of place a sufficient distance to permit the blinds to open at the center and swing clear.

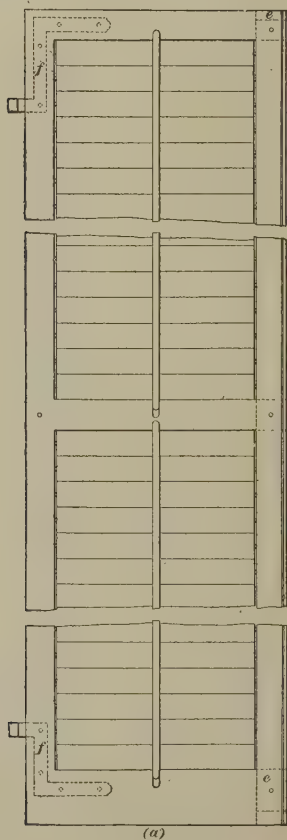
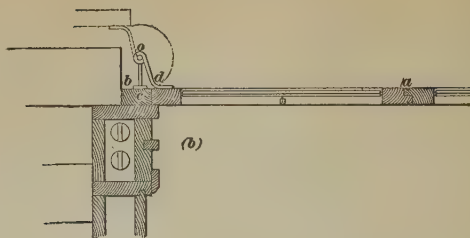


FIG. 62.

103. Outside blinds are laid out with a measuring rod, in the same manner as doors and other framed work, the lengths of stiles and rails, the positions and lengths for tenons, and the location of relishes, etc. being all marked on the measuring rod before any of the actual framework is even started. The positions and proportions of the mortises and tenons in this blind are shown by the dotted lines at *e*, as are also the tightly driven pins which hold the joints in place.

As glue would be useless to secure the joints of outside blinds, owing to their exposed situation, the fixed parts are put together with white lead, as described in Art. 193, of *Carpentry*. The movable joints of the slats, however, require nothing to make them secure, except a proper consideration for the accuracy of construction and the effects of probable expansion and contraction.

104. Fig. 63 shows a section of the top rail of the shutter and four of the slats, or louvers. The thickness *ab* of the stile varies, but is never less than $1\frac{1}{8}$ inches, and the holes shown dotted at *d* are the same in diameter as the slats are in thickness, which thickness varies with the size and weight of the blind. The holes are bored from $\frac{3}{8}$ to $\frac{5}{8}$ inch from the outside of the stile, and should be exactly $\frac{1}{4}$ inch deep. The pins on the ends of the louvers are exactly $1\frac{1}{2}$ inch in length, thus leaving at each end of the slats $\frac{3}{8}$ inch to allow for painting, and to permit freedom of movement.

The louvers are operated by a rod which is attached to each slat by means of two U-shaped staples, one of which is forced into the middle of the edge of the slat, and the other driven

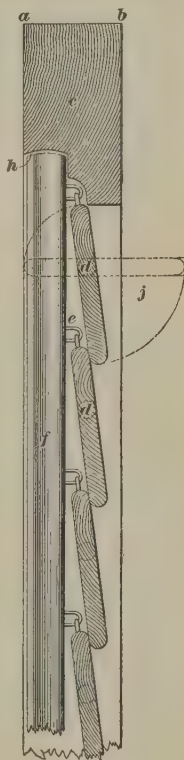


FIG. 63.

into the rod itself, as shown at *e*. Thus, when the rod *f* is pulled down, each of the louvers is thrown to the horizontal position shown by the dotted lines *j*, thereby admitting light and air through the blind.

The top stile *c* is cut out, as shown at *h*, to receive the upper end of the rod *f* and the upper staple when the slats are closed in the position indicated in the illustration.

Blinds of this character are made with two, three, or four panels of louvers, according to the height of the window on the stile of which they are hung, each panel being separated by a horizontal rail from the one next above or below, and each set of louvers being operated by a separate rod, as shown in Fig. 62, except in the case of an unusually high blind, when the upper two sets are sometimes operated by one long rod extending over both panels, and moving in a groove cut across the separating rail, when the slats are closed.

HINGES AND THEIR APPLICATION.

105. Butts, or hinges, are used in hanging doors, inside shutters, lids of chests, boxes, etc. The butt generally used in hanging doors is a loose pin butt; the pin being loose, it can be readily taken out with the fingers, and the door can thus be removed without unscrewing the hinges. To properly hang the door, two hinges, and in case of heavy doors three hinges, are required, the top one being secured 6 inches below the top of the door, and the bottom one, 10 inches above the bottom of the door. Fig. 64 (*a*) shows a horizontal section through the door casing at the hinge. At *b* is the door jamb, back of which are the grounds *f*, extending to the plaster line *j*; *c* shows the door trim, and *g* shows the door stop, against which the door *a* is closed; the projection of the hinge *si* to the center of the pivot is the same as *s' i'* of the elevation of the hinge shown at (*b*), where one flap of the hinge is seen let in and screwed to the edge of the door. This projection of the hinge *s' i'* when the door is opened, as shown dotted at *e*, causes the door to swing twice

the distance $s' i''$, thereby causing it to clear the trim c —a condition always requiring consideration when ordering the hinges.

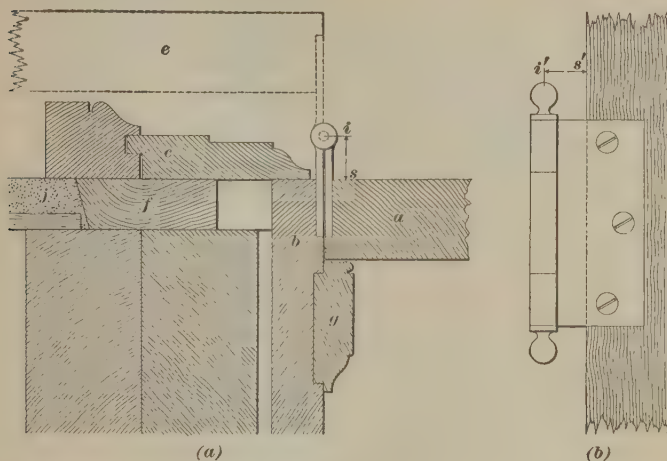


FIG. 64.

106. Fig. 65 shows an inside window-frame casing at e , to which the elbow shutter b is hung. The shutter as it stands in the box is shown at b ; while at a it is shown dotted in position as closed across the window; c shows the flap shutter in line with b when open, and d' shows its position when folded in the box. In hinging the elbow shutter b to the casing e , the whole thickness of the hinge is let into the edge of the shutter, and the flap of the hinge is screwed to the face of the casing e . The knuckle of the hinge should just project beyond the face of the shutter b , as at s . When the hinge is placed as shown, making $a' b' \frac{1}{2}$ inch from the edge of casing to face of shutter, then, when b swings on its hinges to the position a , the edge of the shutter will be at c' , which is $\frac{3}{16}$ inch from b' , or $\frac{1}{16}$ inch from a' ; therefore, in making the shutters, the width must be taken from c' in order to show the $\frac{1}{2}$ -inch margin of the casing when the blinds are open. The flap hinge $i f j$ is screwed to the inside face of

the shutters—keeping the knuckle of the hinge all on the elbow shutter *b*; this is done to prevent the edge of the flap

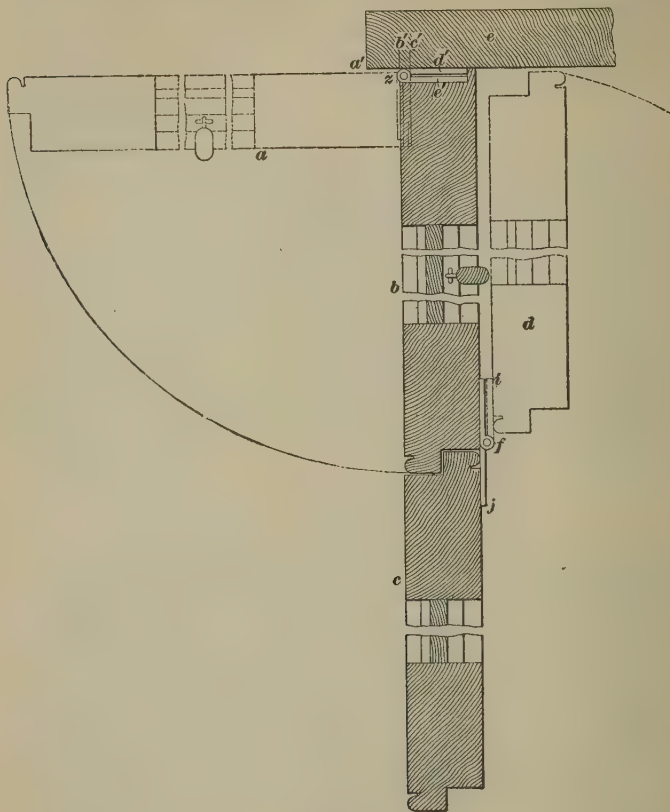


FIG. 65.

shutter *d* from striking, when folding the two shutters in the box as previously explained.

107. Hinging Outside Blinds.—Fig. 66 shows a plan of the blinds of a frame house; *b* shows the position of the blind shutter when closed, and *c* shows the blind shutter opened; at *a* is seen the hanging stile to which one-half of the hinge is screwed, as shown at *h*. The hinge is in two

parts, shown at (*b*), and consists simply of an iron strap *d* with a socket to fit around the pivot *f* which is secured to the other half of the hinge; at *s* is seen the edge of the iron

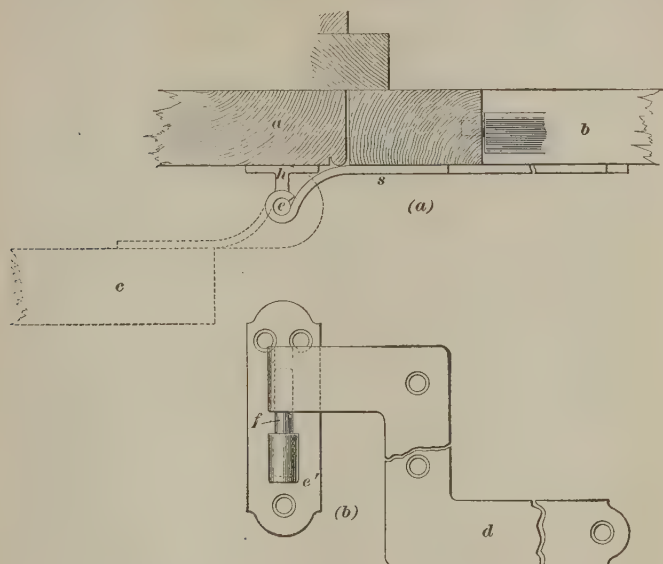


FIG. 66.

strap *d*, which is screwed to the blind *b* and secured with the pivot *f* in the socket *e*.

Outside blinds of brick houses require a hinge very little different from that of a frame house, but the hinge must throw the blind out farther, in order to clear the brick corner.

INTERIOR FITTINGS.

108. Though the location of the fixtures and the arrangement of the pipes in the bathroom are usually considered only in connection with the plumbers' work, the finish of these details and the general interior treatment of the rooms are entirely in the hands of the joiner.

Fig. 67 (*a*) shows the front elevation of the enclosure around

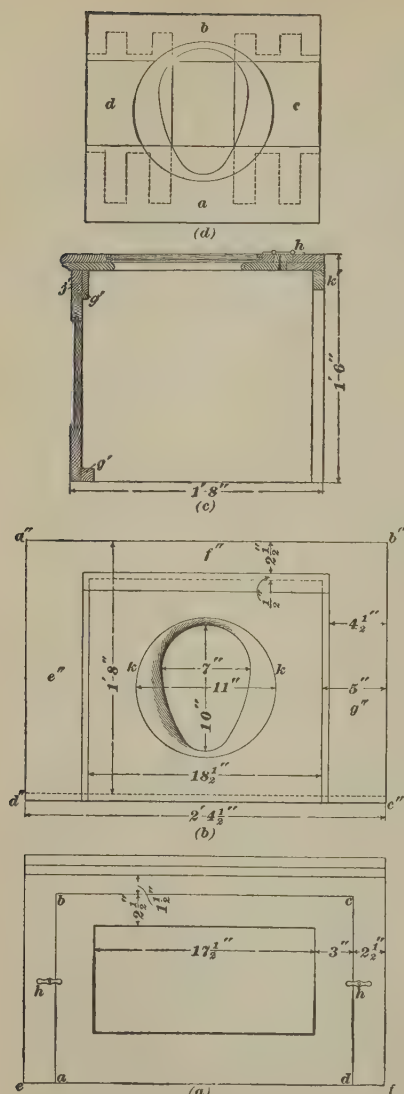


FIG. 67.

the water-closet seat, when such an enclosure is required by the character of the plumbing. The paneled front $abcd$ is framed of $\frac{7}{8}$ -inch stock, and enclosed at the top and ends by the casing $eabcdf$, on the back of which are provided the stops, shown at g' in the section (c), to prevent the panel front from falling inwards, while the two thumb buttons h , Fig. 67 (a), hold it securely in place, but at the same time permit of the front being readily removed to examine the plumbing fixtures.

On top of this front framework is the seat and its cover, or lid, each of which is hinged, so that it may be raised when necessary. This is accomplished as shown in the plan (b), where $a'' b'' c'' d''$ is the outside framework covering the entire top of the water closet and extending the full width of the enclosure, which is usually 2 feet

4½ inches, as shown. This framework consists of three side pieces *e''*, *f''*, and *g''*, and is screwed to the back cleat, shown at *k'* in (*c*) and to the front panel frame *j'*. Within the opening of this frame is fitted the seat *a d b c*, framed of four pieces, as shown at (*d*), the front and back pieces *a* and *b* being mortised on their inner edges to receive the tenons and relishes of the side pieces *c* and *d* as shown by the dotted lines. The opening in the seat is formed at the back with a semicircle 7 inches in diameter, and at the front with a semiellipse whose semimajor and semiminor axes are 6½ inches and 3½ inches, respectively, making the opening 7 in. × 10 in., as shown at (*b*). This opening is splayed out on top and rounded over to the line of a circle *k k* whose diameter is 11 inches. The seat is hinged at its back to the back of the framework *a'' b'' c'' d''*, as shown at *h* in Fig. 67 (*c*). The lid or cover is then made 1 inch wider, but 1½ inches less in depth than the seat, and is fitted over it and hinged to cleats on the top of the framework, as shown. The lid is framed in the same manner as the seat shown at (*d*), but with the opening omitted and with a flush panel inserted in the center; or it may be a plain board with clamps on the end, as described in Art. 19.

109. Washtubs are fixtures which the joiner is frequently called upon to build, and Fig. 68 shows a method of constructing them. At (*a*) is shown a plan of one of these tubs, at (*b*) a vertical section through the tub, and at (*c*) the plan of the cross-piece under the tub, and its joint with the turned leg, as seen at *x* in the vertical section. These fixed tubs are usually built either in a kitchen or laundry, and consist of from two to four divisions. At (*a*) is shown the end tub of a set. The partition *a* and end-piece *b* are seen housed into the front and back pieces *c* and *d*. These pieces *a*, *b*, *c*, and *d* are all 2 inches thick, and are bedded at the joints with white lead. The bottom is dadoed into the sides and secured by means of lagscrews, shown at *e* in Fig. 68 (*b*), and this joint is also set in white lead. At *y y'* is seen a

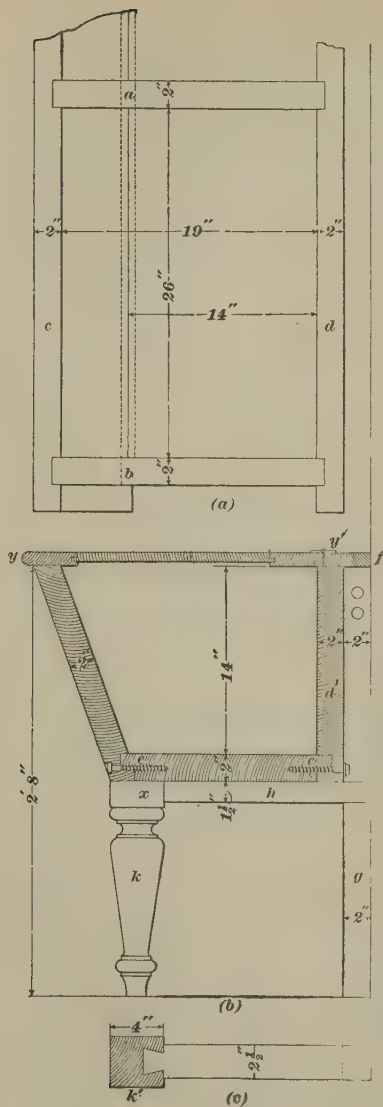


FIG. 68.

paneled cover over the tubs, hinged with a brass hinge at y' , while behind the tubs is shown a 2-inch space for pipes, etc. Extending over three-fourths of the thickness of the back piece d' is a wooden cap f , which finishes the top against the wall. At g is shown a $2'' \times 2\frac{1}{2}''$ support against the wall, carrying one end of the $1\frac{1}{2}'' \times 2\frac{1}{2}''$ beam h , the other end of the beam resting on and dovetailed into the 4-inch leg k , as shown in the plan (c) at k' .

110. Butler's Pantry.—There is no part of a private residence where the joiner is called upon to do so much work in a small space as in the butler's pantry. The pantry must contain a long table for the reception of the dishes, both before and after their service in the dining room; and a sink, well lighted from an adjacent window must be provided, in which to wash them, while a dresser opposite or over the long serving table will receive the dishes after they have been washed,

Fig. 69 shows the plan of a butler's pantry such as might exist in any private city house, the details of which would be applicable to any other residence, either city or suburban. The entrance *a* is provided with a sliding door, for economy

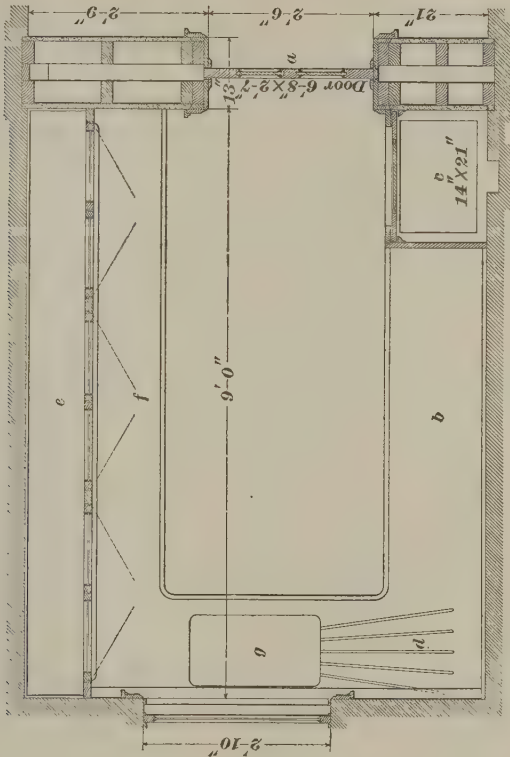
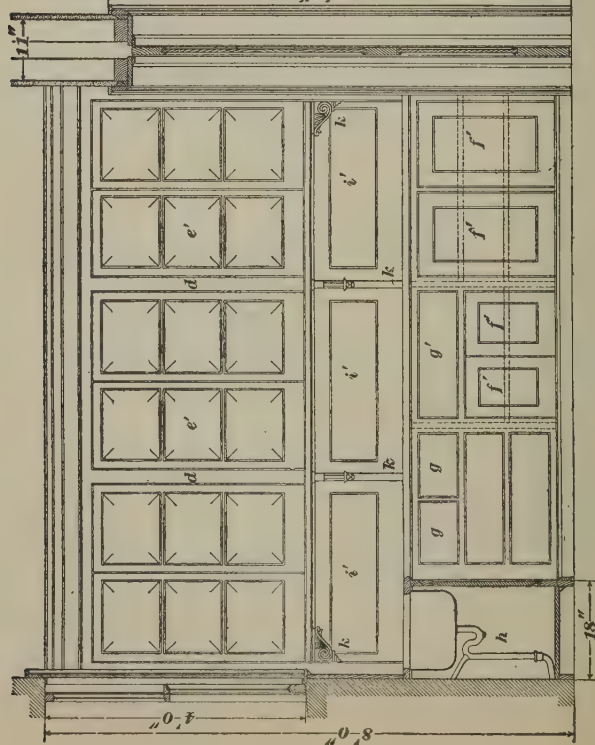
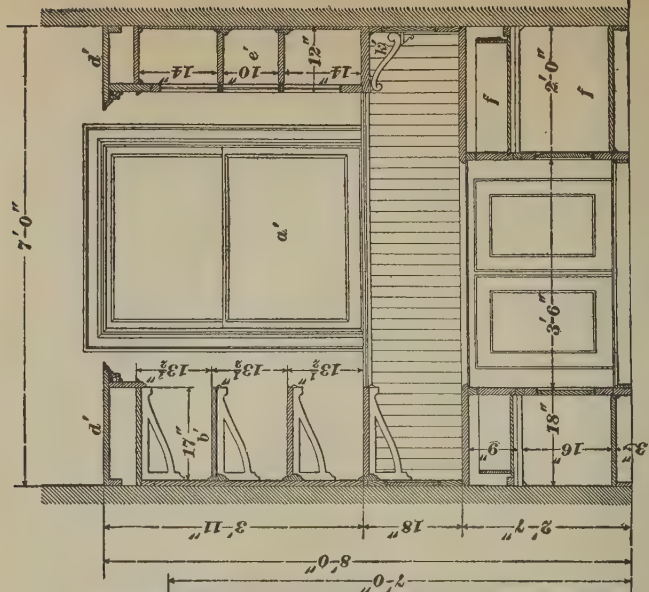


FIG. 69.

of space. On the left at *b* is the long service table 18 inches wide, where the dishes are placed or the carving is done before the food is served in the dining room. At one end of this table is the dumb waiter *c*, while at the other end, at *d*, is the drip board of the sink. Opposite the serving table is *e*, the dresser for the dishes, below which are closets *f*,



and drawers for silverware, dishes, etc., as shown more in detail in Fig. 70.

111. There is no work in the construction of these pantry fittings that has not already been described. The glazed doors of the dresser *e'*, Fig. 70, are constructed in the same manner as a hinged window sash. When the dresser is not over 7 feet long, it is sometimes advantageous to close the front with three glazed sashes, which are plowed with a groove in the top and bottom rails, and are arranged to slide the full length of the dresser on hard-wood or metal tracks, which are secured just far enough apart to permit the sashes to clear one another in sliding. Or they may be made in pairs and hinged as shown on the elevation. The shelves in the dresser may be fixed permanently in place and varnished on both sides, so as to prevent any dust from sticking to them or collecting around the dishes. The drawers *g'* are provided for silverware, such as forks, knives, spoons, etc., and the shelves in the closets underneath are for linen and larger pieces of tableware, which cannot conveniently be put in the upper part.

The glazed closets *e'* are placed about 18 inches above the top of the linen closets *f'*, thus leaving a long narrow sideboard between, the wall side of which is paneled, as shown at *i'*, with plain, flat, unmolded panels, similar to those in the doors below. The glazed closet is secured against the wall, but is supported by means of metal or wooden brackets *k*, placed one at each end of the closet and one under each of the mullions *d*.

In the section shown in Fig. 71, the window at the end of the pantry is seen at *a'*, and immediately under the window is the sink, as shown at *g* in Fig. 69. The board shelves over the serving table are seen in section at *b'*, Fig. 71, and a section through the dresser shelves is shown at *e'*.

When the pantry is built in a suburban residence, it partakes more of the character of a storeroom, and requires at least one chest of smaller drawers, as shown at *g* in Fig. 70, for the storage of coffee, tea, sugar, spices, etc., while at one end must be provided a proper compartment for a barrel or bag of flour.

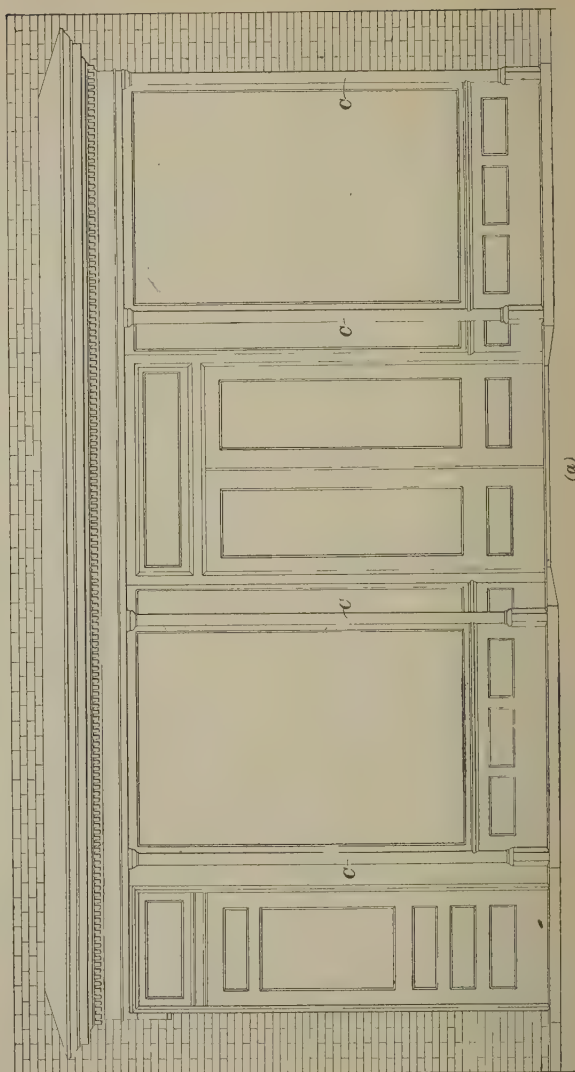
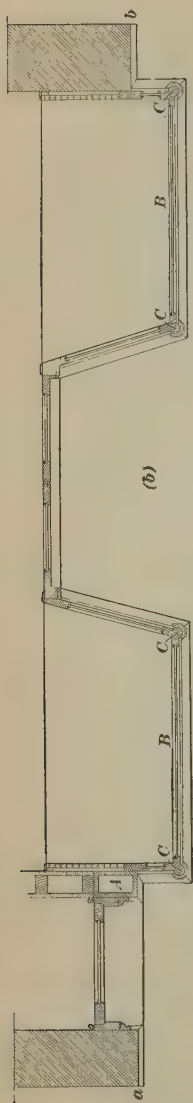


FIG. 72.

EXTERIOR JOINERY.

112. Store Front.—In Fig. 72 (*a*) is shown the treatment usually given a store front, to provide a proper entrance to the store, adequate display windows for goods, and a private entrance to the hallway which communicates with the rooms or apartments over the store. The illustration shows a building 25 feet wide, the side walls of which are of brick 16 inches in thickness, and are built out to the line *a b*, in (*b*), leaving the entire front of the structure, on the ground floor, to be constructed of framework and glass. The brick wall above the first story is carried upon a steel girder, which extends entirely across the building from one side wall to the other, and is set with its outer edge on the building line *a b*. A private entrance and hallway is partitioned off 3 feet from the left-hand side, and the partition separating this hallway from the store abuts an iron column *A*, which, by giving additional support to the girder, materially shortens its span.

113. As the construction of a frame and transom sash, the framing and hanging of a door, etc., as herewith required, have all been previously considered, we will confine our attention to the construction of the windows and cornice of the store front.

The exterior line of the show windows *B* may be on the line of the brick wall *a b*, or it may be permitted to project beyond the building line from 1 to 2 feet, as shown in Fig. 72 (*b*), according to circumstances. In either case, it is necessary to place the door frame of the entrance from 1 foot 6 inches to 2 feet 6 inches inside the building line *a b*, in order to secure a proper depth to the show windows. When the window front is on the building line, or when it is framed and finished down to the ground, as shown in the elevation (*a*), the corners of the window fronts usually consist of more or less ornate, turned columns or angle beads *C*, extending from the stone sill to the under side of the cornice which they appear to support. These columns are rabbeted on

the inside, in order to fit the sash above, and the paneling below.

The paneling is framed together and set in place between the rabbets in the columns, and small joists are carried across to receive the floor of the window. This floor finishes against the panel work on the inside, about 6 inches below the edge of the sash. The top of the window above the columns is finished with a wooden cornice, which also covers the steel beams supporting the upper walls.

114. The details of the construction of the cornice are shown in Fig. 73, where the steel girder is seen at *e*, consist-

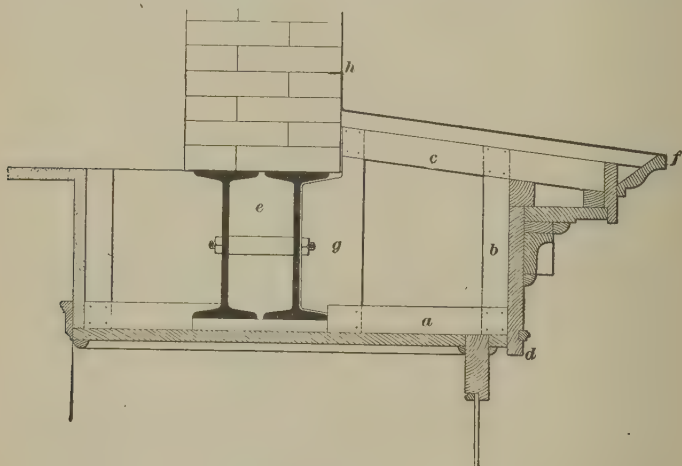


FIG. 73.

ing of two 12-inch beams bolted together, with the wood cornice *df* projecting from the face of the wall in front of them. This cornice is first formed in skeleton form, as shown by the pieces *a*, *b*, *c*, *g*, the last one *g* being cut to fit the form of the girder *e*, thereby giving the cornice a bearing over the opening. This piece is also anchored to the iron beam by means of bolts passing through the girder, and secured to the skeleton of the cornice by means of cleats nailed to the sides. The moldings and soffit of the cornice

are then applied to the skeleton work as shown, and the projecting roof is tinned, or flashed with copper, which in either case must extend up on the wall and enter the brick joints, as shown at *h*.

115. The entrance doors to the store are constructed in the same manner as the front doors described in Art. 44, with the exception of the transom, which should be hinged on the bottom in this case, and provided with proper hardware to permit it to open inwards, in order to give ventilation to the interior.

When a show window projects from the wall of a building, but is not carried all the way to the ground in panels, as shown in Fig. 72 (*a*), the floor of the window is usually carried on ornamental wood or iron brackets, secured in the brickwork below the window, from which they project to the front edge of the framework.

116. There are many other details of joiners' work which have not been separately described, but the principles of construction upon which their framing is based are precisely the same as those herein discussed. The student must learn to apply principles rather than to memorize methods, and when a problem in any form of construction confronts him, he should not try to solve it in a certain manner, simply because it has always been done so before, but should endeavor to comprehend the conditions governing the case, and to study the form of joint and framing best suited to each particular case, and act intelligently, independent of traditional methods.

STAIR BUILDING.

INTRODUCTION.

1. Stair building grew out of the necessity of securing an easy and safe passage from one level, or floor, to another. Such a passage might therefore be regarded in its inception as an inclined plane which connects two horizontal planes and provided with a series of equal risers, or steps, formed for the purpose of giving a sufficient footing to facilitate travel.

The construction of wooden stairways is considered the highest branch of joinery; more care and knowledge are required in their planning, more ingenuity in setting them out, and more skilful workmanship in their execution, than in any other work about a building.

The architect, in studying the plan and treatment of a stairway, should consider its adaptability for the building in which it is to be placed, its proposed situation, the weight likely to come upon it, the width to accommodate probable travel, and, especially, the ease of travel. It is not enough, as is sometimes done, to roughly calculate the treads and risers and sketch on the winders, leaving the stair builder to make the best he can of the conditions.

The first and most important consideration in designing stairways is their disposition for obtaining the utmost facility of access to the various stories to which they communicate. Care should be taken to secure proper headroom while ascending and descending, and the treads and risers should be arranged so as to secure easy travel. The proper width

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of the stairway has also much to do with its appearance; in a private house, it should never be less than 2 feet 8 inches wide, and in public buildings never less than 4 feet 6 inches. The staircase wherein the stairway is enclosed should be given special attention, and the correct length and width should be carefully considered. It is not conducive to sound construction to be obliged to cut out trimmer beams; neither is it good practice to have to piece out a few inches when the staircase has been framed too large.

The importance of proper arrangement of stairways is evident, when it is considered that they are seen by every one, their convenience and beauty being readily appreciated, and their faults and defects instantly detected.

STAIRWAY CONSTRUCTION.

MATERIALS USED.

2. The materials most commonly used in the construction of stairways are stone, iron, and wood; the selection of material should be based on the location and the use to be made of the stairway. If placed outside of a building, stone, owing to its natural capability of resisting atmospheric influences, should be used; while, if placed inside a building designed to be fireproof, iron is generally selected, as it possesses great resistance to heat. Both iron and stone are preferable to wood when used in public buildings, where the amount of travel requires extra strength; wood, however, is the material most commonly used, especially in private buildings, where no heavy travel is to be expected.

TERMS USED IN STAIR BUILDING.

3. In stair building, a **riser** and **tread** together are termed a step, the *riser* being the upright portion which supports the *tread*, or horizontal part, upon which the foot is placed. The **nosing** is the projection of the tread beyond the face of the riser.

The term **run** is applied to the aggregate width of the treads.

Where the risers are parallel to each other on plan, thus forming straight steps, the steps are called **fliers**; but where the risers radiate on plan, the steps are called **winders**.

The term **flight** designates a succession of steps between one starting point and the one next above it. The spaces wider than steps, which constitute resting places between the flights, or which are the terminations of the stairways, are termed **landings**, or platforms. If the landing is square and occupies half the width of the stairway, it is called a **quarter-space** landing; but when it takes in the full width of the stairway, it is called a **half-space** landing. The space required for landings is sometimes filled in by winders; this is especially the case in geometrical stairways and those in which the run is limited. Usually, the required rise and run in the given space decide the nature of the landing, whether it is to be quarter or half space, or filled in with winders. Where the run is unlimited, a half-space landing should be adopted; but where the run does not allow this kind of landing, a quarter space is preferable to winders, as the latter should never be put in a stairway when they can be avoided.

When the lower step of a flight has its outer end in the form of a horizontal spiral, it is termed a **curtail** step. When the outer end of the lower step is rounded to a semi-circle, it is a **bull-nose** step. Where steps have an outward curve, they are called *swelled* steps; this form is generally used when the front stringer is curved out at the starting of the stairway.

If, in ascending a stairway, the hand rail is on the right-hand side, the stairway is called a **right-hand** stairway. If the hand rail is on the left-hand side, the stairway is called a **left-hand** stairway.

The above are some of the more common terms used in stair building; others will be explained as occasion arises for their use.

GENERAL CLASSIFICATION.

4. Stairways are known as dog leg, open newel, and geometrical. A **dog-leg** stairway has no well hole, and the face stringer of the upper flight is vertically over that of the lower one. A **well hole** is the vertical clear space between flights when the stringers are not located in the same vertical plane. The objection to dog-leg stairways is that the hand rail is not continuous, but strikes the soffit of the upper flight.

Where newels are placed at the angles of the well hole, the stairway is termed an **open-newel** stairway; but when the stringer is continued unobstructed by newels in a curve around the winders, the stringer is said to be **wreathed**, and the stairway is designated as **geometrical**.

5. The above classification relates more especially to the general design than to the structural details, many of which

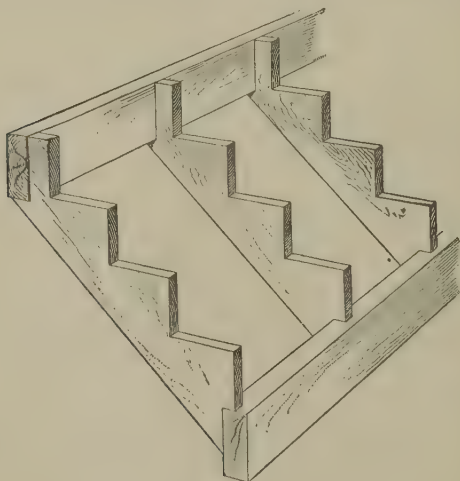


FIG. 1.

are common to each. When classified with relation to the methods of construction, there are two systems: the first consists in the use of rough timbers, or *carriages*, cut to the

angle of intersection between the treads and risers, as shown in Fig. 1; the other, which is the more generally used, has the treads and risers tongued, or *housed*, from $\frac{1}{4}$ to $\frac{3}{8}$ inch, into the grooved stringers. In the first case, the treads and risers are nailed on the carriages, and, where they intersect with the wall, a board of the same thickness as the baseboard connecting with the stairway is *scribed*, or cut, to the required outline so as to fit closely the angles of treads and risers; this runs the full length of the stairway, forming what is termed the **wall stringer**. In favor of this method of construction are its simplicity and strength. Against its adoption may be adduced the great difficulty of satisfactorily scribing the wall stringers, and even when this is successfully done, the stairway is likely, in time, through shrinkage and jarring, to show imperfections.

The carriages, also called **horses** and **springing trees**, for the second form of construction of stairways, are not cut

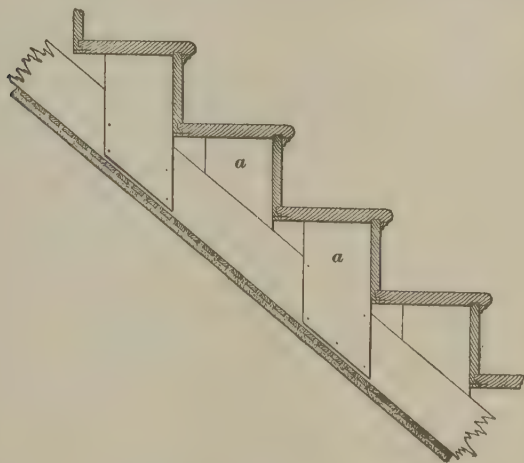


FIG. 2.

to the angle of treads and risers, as is the case in the first method, but are simply straight scantlings of sufficient

strength to support the stairway and its probable load, rough brackets being nailed on the sides of these scantlings and fitted tightly under each tread, as shown at *a*, Fig. 2. In some cases, where the treads and risers are enclosed in stringers, the wall stringer only is housed to receive the treads and risers, the front, or outer, stringer being cut square to receive the tread, and mitered to receive the riser. When thus prepared the front stringer is termed a **cut-and-mitered**, or **open**, stringer, the wall stringer being termed a **housed** stringer. Occasionally both wall and front stringer are housed, in which case the front stringer is said to be a **close** stringer. Geometrical stairways are seldom thus constructed, the method being mostly confined to dog-leg and open-newel stairways.

In geometrical stairways, the front stringer is cut and mitered so as to meet the conditions arising from the wreathed portion of the stringer and rail, which are assumed to be parallel to each other in the same vertical plane. The rail in this case is supported by the balusters and **starting** newel, instead of by newels, and the cut-and-mitered stringer affords a substantial footing to the balusters, which are dovetailed, glued, and nailed to the ends of treads; the nosing and molding of the treads being returned their full width on the face of the stringer. Stairs thus constructed are said to have *nosed* and *mitered* moldings, and when brackets are placed along the front stringer below the nosing, the stairway is known as a **bracketed** stairway.

DETAILS OF CONSTRUCTION.

RISERS AND TREADS.

6. Height of Risers.—In setting out a stairway, the first consideration should be to ascertain the exact height between the floors, the height to be measured from the top of the floor below to the top of the floor above. For this

purpose, a rule or rod is sometimes used, termed a **story rod**, on which the whole number of risers is to be marked. Care should be used in determining the risers, with the view of constructing a stairway having steps of convenient height. Experience teaches that between 6 inches and 7 inches rise is the limit of easy stepping; therefore, the total height of the story rod should be divided by either one of these numbers, which will give the number of risers required. Having in this manner ascertained the number needed, divide it into the height of the story rod; the quotient will be the exact height of each riser.

7. Proportioning Treads and Risers.—The next step is to ascertain the width of the treads, not forgetting the rules of proportion between treads and risers, and always remembering that the number of treads in each flight is one less than the number of risers; this is owing to the landing not being counted as a tread.

There are several rules for determining the proportion which should exist between tread and riser for regular stairways, and upon which depends not only the appearance of the stairway, but the ease with which it may be traveled.

Three rules will be given, of which the first is the simplest, and is generally preferred.

Rule I.—*Let the product of the tread and riser equal the number 66.*

For example, assume that the riser is six inches high, then the width of the tread will be $66 \div 6 = 11$ inches. In the same way, the width of tread may be assumed, and the height of the riser found.

Rule II.—*To any given height of riser in inches, add a number that will make the sum equal 12; double the number added, and the result will be the width of the tread in inches.*

For example, assume that the height of a riser is 7 inches; then $7 + 5 = 12$, and $5 \times 2 = 10$, the width of the tread in inches.

Rule III.—*Draw a right triangle, as shown in Fig. 3, with a base of 24 inches and altitude of 11 inches. Mark the width of tread from a on line a b, as a c; at c erect a perpendicular, cutting the hypotenuse at e. Then c e indicates the riser.*

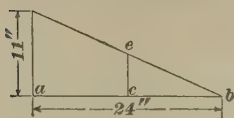


FIG. 8.

HEADROOM.

8. In trimming joists of staircases, the two cross-beams which are called *headers* should be so placed as to allow sufficient headroom to meet all probable requirements of a stairway. The header (which determines the headroom) should be placed so as to secure 7 feet of headroom from the tread vertically beneath it. A careful drawing of the elevation of the stairway will accurately determine this point.

In cases where a number of winders are placed at the bottom of a stairway, and the risers thereby stand one above the other at the center from which they radiate, a considerable rise is produced at the commencement of the run, the amount depending on the number of winders. In such a case, the header is placed at the extreme end of the staircase, and thereby ceases to be a factor in the headroom. This applies especially to *boxed stairways*, which are enclosed between partitions.

Care should be taken to make the staircase of the correct width, which should be at least 5 inches wider than the stairway; that is, the distance across the cylinder from the center of the rail of the flight to the fascia of the floor landing should be at least 5 inches, to permit the rail of the flight to pass clear of the nosing on the landing.

STRINGERS.

9. **Laying Out.**—A straight stringer is laid out by means of a *pitch board*, shown at (a) in Fig. 4. This board should be made of thin wood, with the grain parallel to the hypotenuse, so that the effects of shrinkage will be the least

possible. The base is cut to equal the tread, and the perpendicular to equal the riser. At (b) is shown the stringer, as marked out for the steps; the dotted line ab is drawn at a sufficient distance from the edge, so that the lower edges of the riser and tread will intersect on the line of the under side of the stringer, as shown at d . On the line ab , step off, with dividers, distances equal to the slope length of the pitch board. The latter may then be applied as shown, and its outline marked on the stringer edges. Templets, as

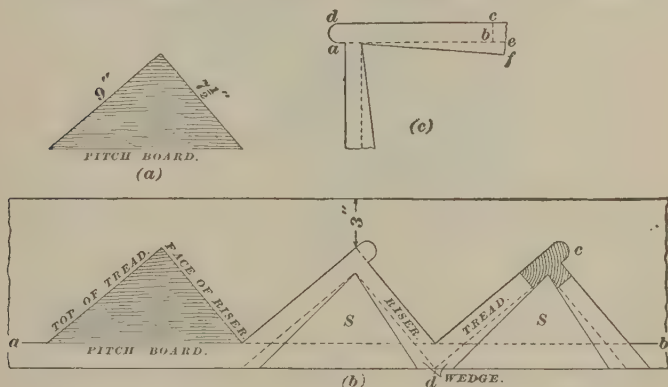


FIG. 4.

shown at (c), should be made for the treads, risers, and wedges, care being taken that the pitches are alike, so that the same shaped wedges can be used. The lines $adcb$ show the section of the tread, and aef shows the shape of the wedge. The tread and riser templets, when applied to the stringer, should have their outer edges coincide with the lines made from the pitch board, giving the outline shown at S .

To form the housing, holes are bored in the stringers adjacent to the nosing of the tread, as at c , and that portion is removed by means of a chisel. The lines of the templets may then be cut to the depth of the groove by a saw, and the material removed with a router plane.

Such a stringer is shown in Fig. 5, with the exception

that the under edge is kept somewhat lower than the point *d* in Fig. 4, and is preferable to the latter method in that the wedges are well supported at their outer ends. If the staircase will allow the insertion of the assembled parts, the

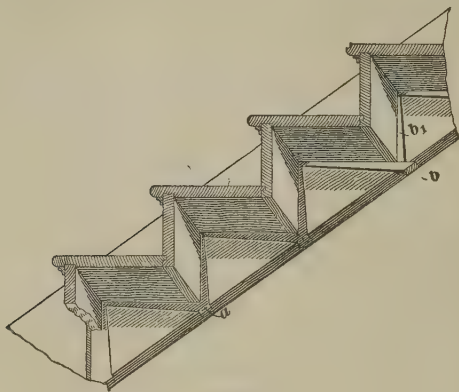


FIG. 5.

treads and risers are attached to the stringers, wedged, and glued into the housing, and the whole taken bodily to its place in the building. The wedges are shown in place at *a* and *b*, Fig. 5.

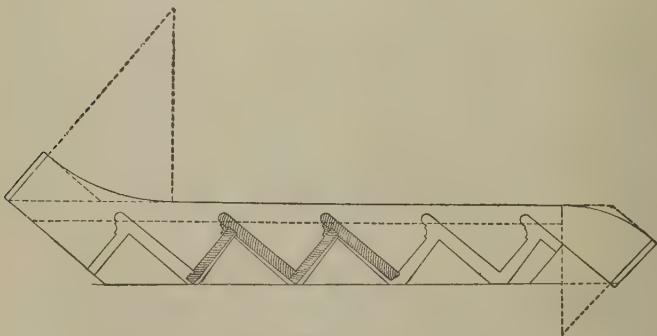


FIG. 6.

The wall stringer, as shown in Fig. 6, and also the front stringer, if a close one, are each grooved as already explained.

the depth depending upon the thickness of the stringer. Two or more carriage timbers are used in the width of the stairway, the number, depth, and thickness depending on the width of the stairway and the load to be carried.

The front stringer, as shown in Fig. 7, is well nailed to the front carriage timber *a*, while the other timbers are rough

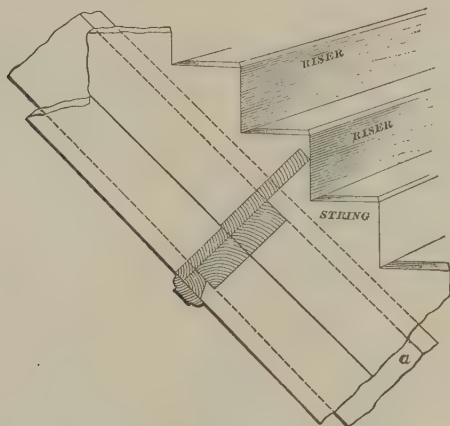


FIG. 7.

bracketed under each step alternately on the sides, and nailed as shown at *a*, Fig. 2. A furring strip is nailed to the wall in line with the lower edge of the carriage timbers, to receive the lath.

The prepared mortised wall stringer is nailed to the wall to square properly with the previously set carriage timber and front stringer.

10. Scribing Wall Stringers.—When the treads and risers are supported by rough cut carriages, it becomes necessary to cut a wall stringer that will fit around the steps and make a finish with the wall. In Fig. 8 is shown a method of *scribing* a wall stringer. The stringer is represented as being laid with one edge on the line of the nosings,

and the instrument to be used is shown in position. The hard-wood or iron bar bh has a hook on the lower end projecting sufficiently to enable the bar to clear the nosing when the point b is touching the face of the riser. The bar bh is placed against the guide m and loosely bound to it by the

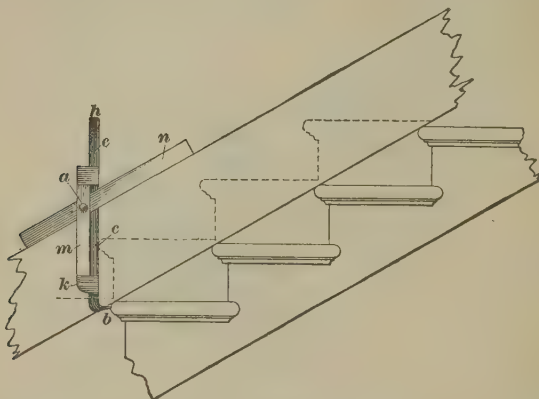


FIG. 8.

metal straps e and k . The strip n is fastened to m by a bolt a , which can be tightened so as to preserve the bevel. A small nick is made in the sliding bar bh at c , so that bc is the height of a riser. When the point b is on the end of the nosing, the nick c gives the position of the corresponding point on the wall stringer. Other points may be found in a similar manner, and the outline to which the wall stringer is to be cut can then be drawn.

CONSTRUCTION OF STEPS.

11. A portion of the upper edge of the riser may be tongued into a groove in the under side of the tread, as shown at a in (a), Fig. 9, instead of letting the whole thickness of the riser into the tread, as shown at b in (b). The lower edge of the riser may also be tongued into a groove in the upper

surface of the tread beneath it, as shown at *b* in (a), in which case the tread would have to be nailed up into the riser as at *c*; this method, however, does not give as good results as that shown at *a* in (b).

The finished treads and risers are glued, and clamped together with handscrews until the glue has set. From two to four well fitted blocks are then glued and nailed to the internal angle of the tread and riser, as shown at *b* in (b). In Fig. 9 (b) are also shown the dovetails for inserting the balusters.

12. Bull-Nose Steps.—A form of step

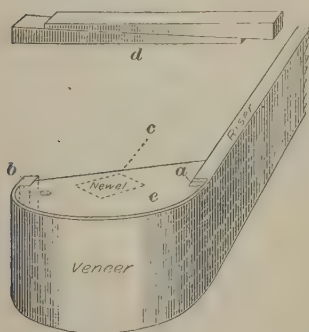


FIG. 10.

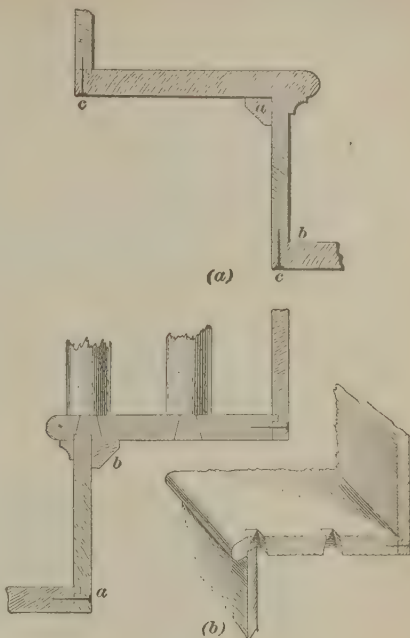


FIG. 9.

much used is represented in Fig. 10. The solid block *e* is sawed into shape, and the riser is sawed out as shown, leaving a veneer for the face of the block. The end *b* is firmly fastened to the solid block with screws. At *a*, a square hole is left the full depth of the riser, into which wedges are driven from each end, as suggested at *d*. The back of the veneer is covered with glue, and, as the wedges are driven home, it is clamped

firmly against the face of the block. The newel is generally set on top of this step, as indicated by the dotted lines. The second riser may be placed in line with the middle of the newel, as indicated at *c*, or in any other position desired.

13. Curved Risers.—Where risers are curved, they should be made of solid wood, or of curved strips of seasoned wood glued solidly together. It is often difficult to get seasoned wood in pieces large enough to make a solid curved riser. In such cases it is desirable to bend pieces of 1-inch board by kerfing. Fig. 11 illustrates the method of finding

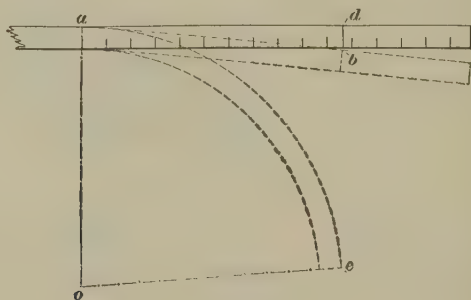


FIG. 11.

the distance between kerfs for a curve of given radius. The method is as follows: Cut one kerf, as at *a*; then, marking the distance *ad* equal to the radius *ao* of the curve to which the piece is to be bent, bend the board to position *ab* until the saw kerf is closed, as shown. Measure the distance between *d* and *b*. This length *db* is therefore the distance between kerfs, which, if continued, will shape the board to the curve *ac*. All the kerfs must be made with the same saw and to the same depth.

14. Platforms.—Where the stairways of a building are of considerable length, and are straight in plan, it is best to break the flight by a platform. Such a platform may be projected from the side wall, as shown in Fig. 12. In a

brick wall, the lookouts *a, a* should be set in at least 8 inches with slip keys tightly wedged between the bricks and the top of the timbers. In frame walls the lookouts are nailed

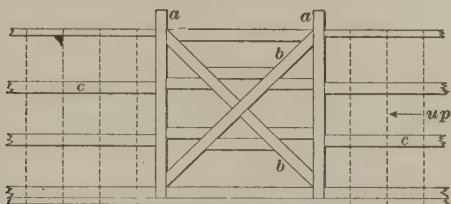


FIG. 12.

to the studs. The braces *b, b* should be well fitted and spiked to the lookouts; these braces serve to keep the platform square, and should be made of thoroughly seasoned

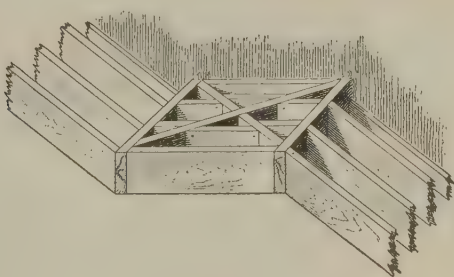


FIG. 13.

wood. A flight terminating in a platform should not contain more than 12 steps. A perspective sketch of the platform is shown in Fig. 13.

CYLINDERS.

15. In a geometrical stairway, the hand rail travels, unobstructed by newels, from the first step to the last, sometimes over six or more flights; it then becomes necessary to wreath the stringer and rail around the well hole. The

well hole thus treated is said to contain a **cylinder**. The cylinder is the curved space around which the hand rail and stringer are wreathed. In a circular stairway, the cylinder assumed has a complete circle for its plan, and the stringer and rail are made to wind around it, following a curve termed a *helix*—a curve of the same nature as the winding thread of an ordinary screw. The finished treatment of the stringer and balustrade is continued around the cylinder, and where the stairway terminates in a landing, the same treatment is continued along the trimmer beam. The finishing piece on the face of landing beam corresponding to the stringer of the flight is called the *facia*. Thus it will be seen that the stringer of the flights, the cylinder of the well hole, and the facia of the trimmer beam are but parts of one **continued stringer** known by different terms.

Cylinders are built up as shown in Fig. 14. The construction shown at (a) is used for small cylinders, while for larger ones, the methods shown at (b) and (c) are used. The joints, as *st* and *vz*, are glued and strengthened by screws or wooden dowel-pins. For extra fine work the face of the cylinder is veneered, so that the joints of the staves in the semicircle from *a* to *b*, in (c), are covered. The veneer is bent over a skeleton cylinder whose diameter is equal to the diameter of the well cylinder, and then backed with properly fitted staves, as *c* and *d*, well glued, and screwed or doweled at the joints, if necessary.

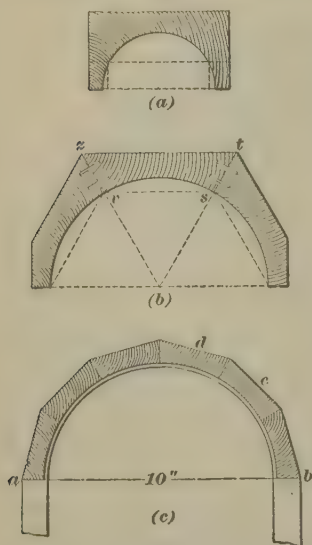


FIG. 14.

common methods are shown in Fig. 15. In the first method

(a), a dovetailed groove is cut in the stringer into which the end stave fits. Wedges *W*, glued in, hold the stave in place.

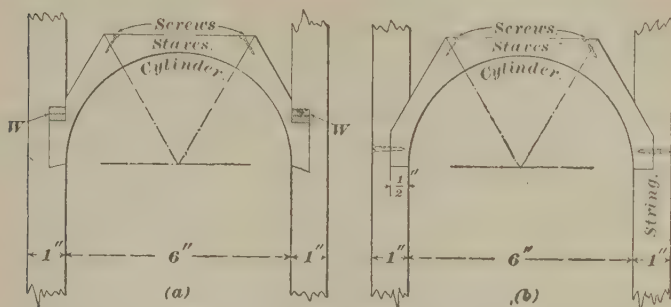


FIG. 15.

In the second method (b), the end staves are merely set into the stringers and screwed fast from the outside.

MISCELLANEOUS DETAILS.

16. Moldings.—All base and stringer moldings should be worked out of solid wood. Work that is to be bent is generally stronger when laminated, as shown in Fig. 16; but for moldings this method cannot always be used, since the joints will show, no matter how well the work is done. This is particularly true of hard woods. If the work is to be painted, however, this method is not objectionable.

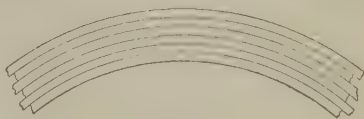


FIG. 16.

17. Erection.—If the stairway is put up against the brown-mortared wall, the finished parts must be well covered with building paper, and rough boards placed over the paper on the treads, to remain until the interior woodwork is completed. The covering must be fixed in such a manner as to permit enough of it to be easily removed to allow the hand rail and balusters to be put up.

When the steps are set in place, they should be carefully inspected to ascertain if any of them are cut short and pieced, if any of the wedges are improperly glued, or the nailing of treads and risers omitted. When a person ascends or descends the stairway, it should make no creaking noise, as even a slight creaking is sure to grow louder in time and be a lasting reminder of defective work. Creaking is generally due to defective gluing, nailing, wedging, or to the use of unseasoned stuff in either the rough carriages or the finished material.

BALUSTRADES.

18. Newel posts, or newels, are used to support the hand rail, and are either made of solid materials and turned, or built up, box-like, in which case they are called *boxed newels*. They vary in design, form, and size, some—especially the one placed at the bottom of the stairway, called the *starting newel*—often being elaborately decorated with panels and carvings.

The newel is also variously fixed in its relation to the steps adjoining. In ordinary cases it is placed on the floor, and when so placed its center should be in line with the center of the first riser. Where space is limited at the bottom of a stairway, the newel may be placed on top of the first step, and even on top of the second or third step; but in each case, it is desirable to place it so as to have the center of the riser in line with the newel center, and the steps outside rounded, and returned into the stringer; the end of the latter being inserted in a prepared mortise in the center of the newel.

The *angle newels* on the landings are generally smaller in size and have less decoration than the starting newels. The same rule applies to their relation to the risers; viz., that the center of the riser should be in line with the center of the newel. Working from centers in stair-building construction is almost a maxim. The center of the rail is to be in the center of the newel; so, also, is the center of the stringer; and the center of the baluster is to be in the center

of both stringer and rail; and, as before mentioned, the center of the riser adjoining the newel is to be placed at the center of the latter.

19. Balusters are small columns, generally turned, set vertically on the ends of treads or on the stringer, forming an ornamental guard, and supporting the hand rail. When the front stringer is closed, or housed, the balusters are fixed to the stringer, instead of to the treads, a grooved molding, called a *cap*, being prepared to receive them; the lower ends of the balusters in this case are cut to the pitch of the stairway, and the top is either cut to the same pitch as the rail, or mortised into it. This applies to balusters having square ends. Frequently they are made square or round at the bottom, and turned to a spindle shape at the top, being then termed *pin balusters*. Balusters with square bases are preferable to those with round bases, as the square base gives bearing surface and resistance to movement almost double that of a round base. Holes are bored about an inch deep into the under side of the rail to receive the balusters, and the lower ends are either cut to the pitch of the stairway or dovetailed to the ends of the treads, depending on whether the stringer is housed or cut and mitered.

In ordinary stairways, two balusters are used to each tread, but in the better class of stairways, the number is increased, adding thereby to the beauty and strength of the balustrade, and general appearance of the stairway. With two balusters on a tread, they are placed half the width of a tread apart between centers, the short one standing close to the nosing and the long baluster being placed midway between the adjacent nosing balusters, so that it is exactly one-half the rise of the steps longer than the short one on the same tread. The usual height of pin balusters is either 2 feet 4 inches or 2 feet 8 inches, of which 1 inch is allowed at each end for insertion into rail and tread.

In extra fine stairways the space between the balusters is filled in with brackets of various designs, or the space is paneled, in either case the number of balusters is reduced

to one for each tread, ordinarily placed over the face of each riser, thus leaving the full width of the tread (less the thickness of one baluster) for the decorative brackets or panels.

20. Hand Rails.—The development of hand rails, which involves complex geometrical problems, is not within the province of the architect or builder, though a few remarks regarding their construction are pertinent. The rail—except where placed over winders, whether at the bottom of the stairway or around the cylinder in the well hole—should be set parallel to line of nosings. The pitch over the winders will be more inclined than it will be over the straight rail, and as the amount of the inclination determines the height of the rail, it follows that additional inclination over the winders requires more height for the wreath; but this addition in height should never be such as to cause an unsightly crippled appearance where the curve of the wreath intersects with the straight rail. In stair construction each baluster should be vertical, and solidly glued and nailed to the hand rail, so that when tested, there should be no noise, which would indicate the presence of loose balusters through imperfect fitting, poor gluing, or carelessness in nailing.

Where the straight rail enters the newel without a ramp, it allows the newel to be made from 4 to 6 inches shorter than would otherwise be possible, the reduced height being often a matter of some consideration. Where such is not the case, the hand rail may be bent upwards (in which case it is said to be ramped), so as to enter the newel in a plane perpendicular to it, and the angle of intersection between the raised level portion and the inclined plane of the straight rail is gracefully eased. This last method is the one most commonly adopted, owing mainly to its superior ornamental characteristic.

21. Ramps and Easements.—In an open-newel stairway the rails usually meet the newels one above the other. To bring them to the same level, the rail must be ramped, and sometimes they are ramped and *kneed*—the latter being a concave easement with its upper end forming an angular knee.

When the knee is convex, the combined curve is then called a *swan neck* or sometimes a *goose neck*. The lower ends of rails abutting against the newels may be either straight or curved. When curved, the rail is said to be *eased*, and the curved portion of the rail is called the *easement*, and this arrangement requires the newel to be somewhat longer.

22. Stiffening Hand Rails.—Continued hand rails are sometimes provided with an iron brace extending across the cylinder from the facia to the bottom of the rail. Instead of

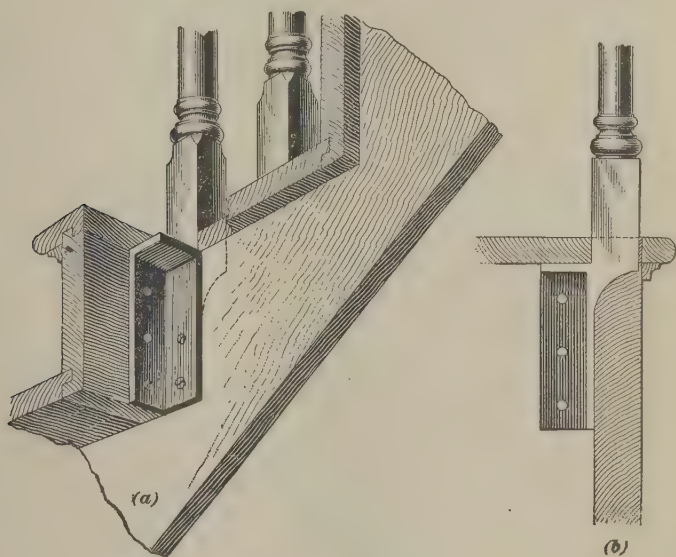


FIG. 17.

this brace, an iron baluster is often placed at each end of the wreath. Fig. 17 (a) is a perspective sketch of the base of such a baluster, which is formed into a flanged connection and attached to riser and stringer by screws. At (b) is shown a side elevation of the base, and its relative position with reference to the face stringer.

STAIRWAY DESIGN AND CONSTRUCTION.

ORDINARY FORMS.

23. Step Ladders.—One of the simplest forms of stair-

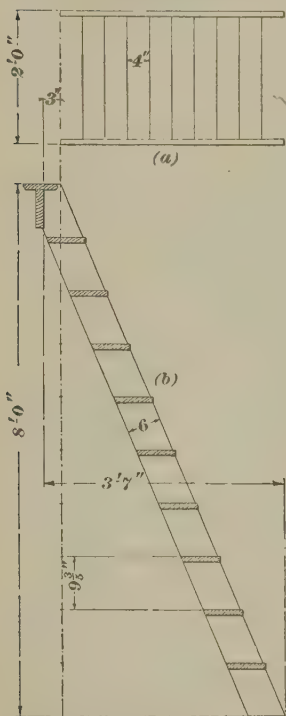


FIG. 18.

ways in use is a step ladder, fixed or movable, such as is sometimes built from an attic floor to the roof, as is shown in Fig. 18, where (a) is a plan, and (b) an elevation. The top step should always have an increased width, and the sides of the ladder should be at least 6 inches wide by $1\frac{1}{8}$ inches thick. The steps are *gained* into the sides not less than $\frac{3}{8}$ inch and securely nailed or screwed thereto. This ladder rises 8 feet, or 96 inches, which, divided by 10, the number of steps, gives $9\frac{6}{10}$ inches for each riser. The horizontal distance from the face of the landing beam to the bottom of the ladder equals 3 feet 7 inches. This distance, less 3 inches for additional width of top step, leaves 3 feet 4 inches, or 40 inches, which, divided by 10, the number of treads, gives 4 inches as the width of each tread from

its nosing to a vertical line dropped from the nosing above.

24. Plank Stairway.—In (a) and (b), Fig. 19, are shown the plan and elevation of a strong stairway, such as may be required for a shop or factory; *a* and *b* are newels, 6 inches

square, to which $3'' \times 1\frac{1}{2}''$ hand rails c and d are fastened and

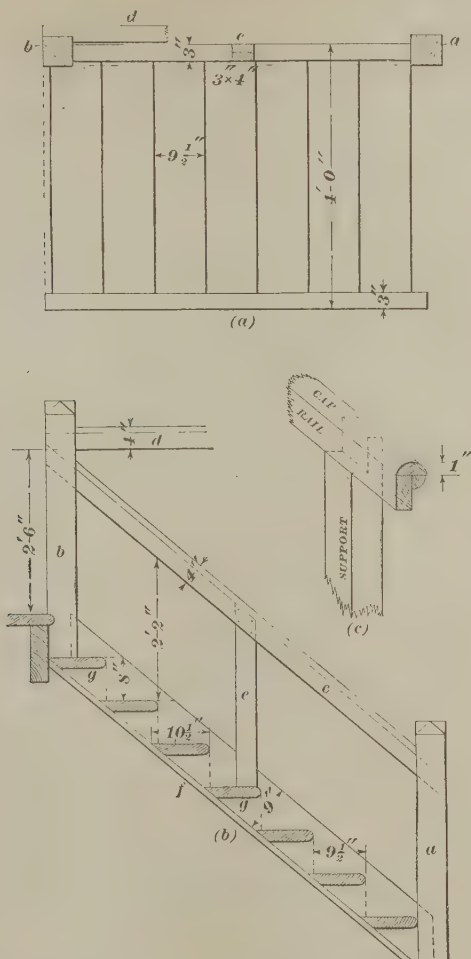


FIG. 19.

braced with one or more uprights e . At (c) is shown a section of the hand rail. Hard-wood treads g , 2 inches thick,

are mortised 1 inch into 3-inch timber stringers, tightly fitted into the mortises and well spiked, but not wedged. The soffit may be ceiled with matched lining, as at *f*.

GEOMETRICAL STAIRWAY.

25. Straight Stairway.—In Fig. 20 are shown the plan (*a*) and elevation (*b*) of a straight stairway with a 6-inch

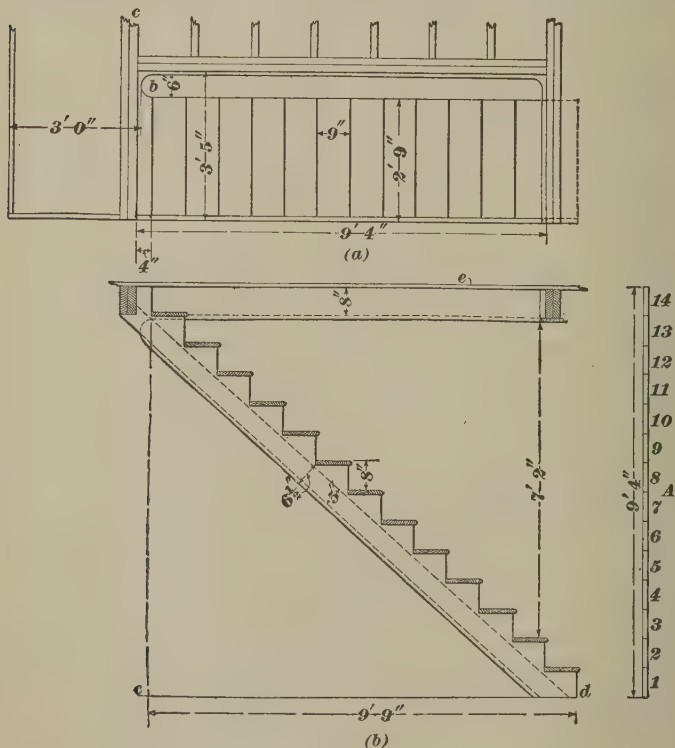


FIG. 20.

cylinder. The first requirement in planning this stairway is to fix the number and height of risers. The story rod *A* indicates the height of the story to be 9 feet 4 inches, or 112

inches, which, divided by 14, the number of risers, gives 8 inches as the height of each riser. The total run cd is 10 feet 1 inch, less 4 inches for the depth of the cylinder, which leaves 9 feet 9 inches to be divided into 13 treads, giving 9 inches as the width of each tread. As the floor at the landing makes one of the steps, there is one tread less than there are risers. The width of the stairway, shown in (*a*) as 2 feet 9 inches, is measured from the face of the plaster to the face of the front stringer, while the width of the well includes the width of stairs, the diameter of the cylinder (in this case 6 inches), plus 1 inch for the thickness of the fascia, and 1 inch for lath and plaster—altogether 3 feet 5 inches; and if the outside wall be constructed of brick, 1 inch more for thickness of furring will be required. At the landing of a straight flight, there must be at least as much room between the cylinder and the partition as the width of the stairway, preferably as much more as possible. In this case 3 feet is the width used in the platform, the 3 inches extra being allowed for convenience in moving furniture, etc.

The headroom of the stairway shown in Fig. 20 is 7 feet 2 inches from the top of the second step to the ceiling, and the point where this headroom can be secured governs the length of the well hole—as figured on the plan, 9 feet 4 inches. It is not necessary to make a drawing of the elevation in order to find the length of the well hole for the required headroom, as this can be calculated from the plan, by counting 12 risers down. If each riser is 8 inches, the 12 risers make 96 inches. From 96 inches subtract 10 inches, the depth of the floor, giving 7 feet 2 inches as the headroom. The 12 treads, of 9 inches each, make 9 feet, to which must be added 3 inches for the depth of the cylinder, and 1 inch for its thickness, making the total length of well hole 9 feet 4 inches.

The hand rail for such a stairway as this would be from 3 to $3\frac{1}{2}$ inches wide, and the balusters from $1\frac{1}{2}$ to 2 inches, square or turned.

26. Platform Stairways.—The plan (*a*) and the elevation (*b*) of a half-turn platform stairway, with a continued

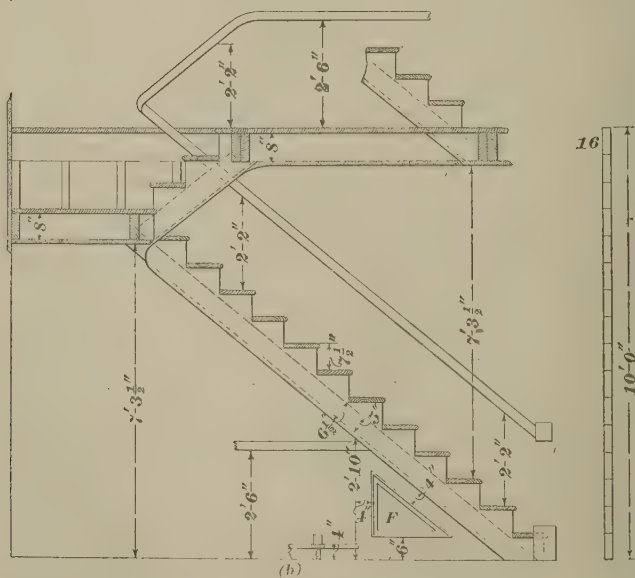
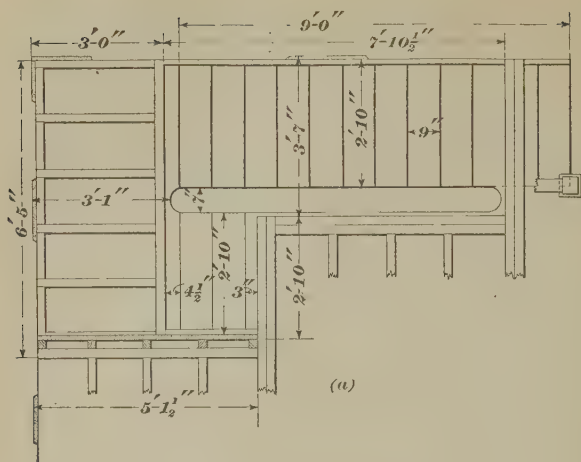
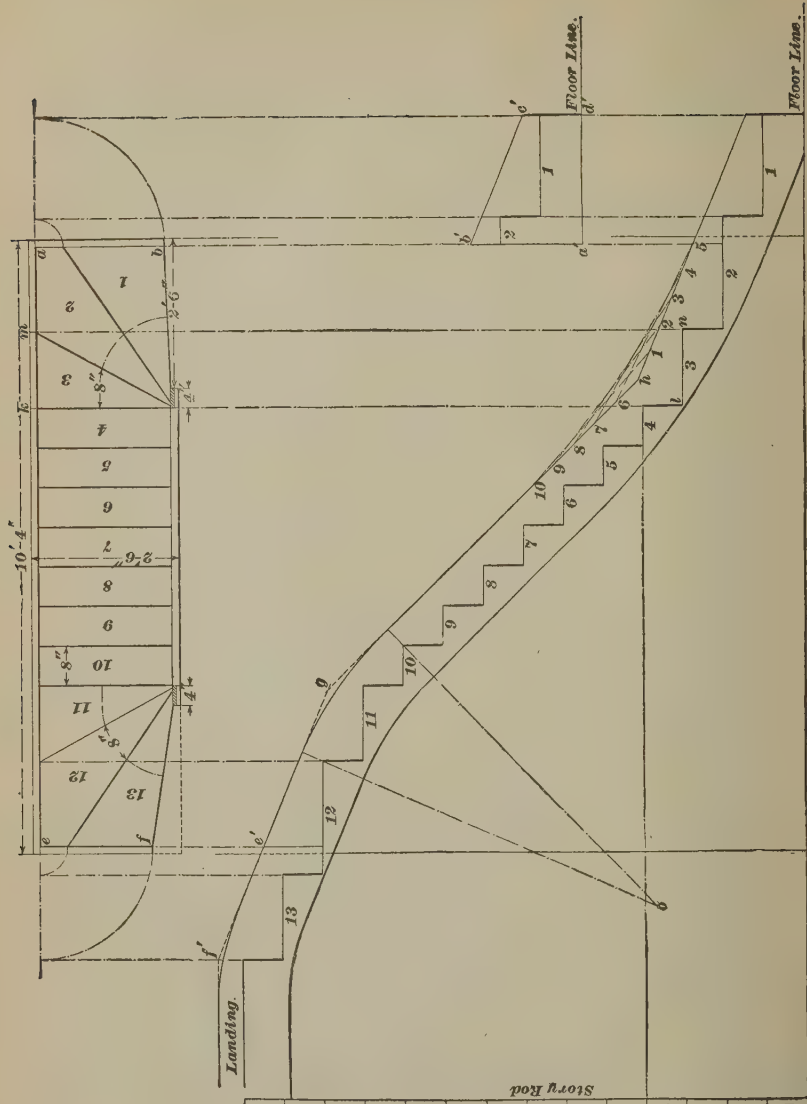


FIG. 21

hand rail around a 7-inch cylinder, is shown in Fig. 21. This kind of a stairway is easy of ascent, breaking the flight, as it does, with a roomy platform, and allowing space for a window to light the stairway and hall from above the platform, while below it affords room for a doorway to the outside. With the last mentioned purpose in view, the soffit of the platform must not be less than 7 feet in height. The plan indicates also the timber framing of the well and the platform. A jib panel *F* is shown at the start of the stairway in the elevation (*b*), the object of which is to close and neatly finish the angular space formed by the intersection of the stringer and the floor. The height of the jib panel is such as to receive the hand rail of the basement stairway. Where it is desired, the latter stairway may be enclosed by a paneled or lath-and-plaster partition extending up to the stringer of the upper flight.

The hand rail on the flight is 2 feet 2 inches in height from the center of the short baluster at the top of the step to the bottom of the rail: along the hallway the bottom of the rail is 2 feet 6 inches from the floor. These heights are based upon the commercial custom of turning ordinary pin balusters in lengths of 2 feet 4 inches and 2 feet 8 inches, 1 inch being allowed for entering the hand rail and 1 inch for the dovetail entering the tread, thus leaving the exposed part the length mentioned.

This kind of platform stairway can be altered in various ways, without changing the number of risers. For instance, a step can be taken from the upper flight, and added to the lower flight, increasing the run 9 inches and raising the platform one riser, making it 7 feet 11 inches. Then the well hole for the same headroom must be 9 inches longer, and the beam at the landing of the short flight must be brought forward the same distance. On the other hand, a step may be added to the short flight, making 4 risers in the short, and leaving 12 risers in the long flight. The well hole can now be shortened 9 inches, and have the same headroom as before; but it will be necessary to move the landing beam of the short flight back 9 inches, to accommodate the



additional step. The platform, however, is one riser lower, making it 6 feet 8 inches; but if the total depth of the platform can be made 6 inches, thus reducing its depth 4 inches, the height to the soffit of the platform will be 7 feet.

27. Winding Treads.—In Fig. 22 is shown an enclosed stairway, illustrating the method of laying out the wall stringer, easement curves, etc. The widths of the winding treads at the wall are projected down from the plan by lines *kl*, *mn*, etc. Then the wall stringer *ab*, at right angles to the main wall stringer *ac*, is revolved as shown, parallel to the main wall stringer and laid out in a similar manner; *a'b'c'd'* shows the stringer *ab* in elevation. The stringer *ef* is treated in a similar manner. The story rod is shown at the left, and the steps are projected from it and from the plan, as shown at step 4. Where the treads are wide, as in steps 1, 2, and 3, the line of the nosings makes an angle with the horizontal different from that made by the line of the nosings in the body of the stairway. This is because the uprights, or risers, remain the same, while the horizontals, or treads, vary in width.

28. Easement Curves.—At the angles, easement curves are necessary, or, at least, advisable. At *h* is shown a method of drawing an easement curve. From the vertex *h* lay off equal distances in both directions, as 1, 2, 3, 4, etc. Draw lines from 5 to 6, 4 to 7, etc. Through the points of intersection of these lines, draw a curved line by means of a spline. If the angle is sharp, as at *g*, perpendiculars may be drawn at equal distances from *g* until they intersect, as at *o*; the curve can then be drawn with a compass.

29. Items of Detail.—Both wall and front stringers are to be mortised, or housed; for the steps, the treads and risers are to be glued together, wedged and back nailed, as before explained, in order to secure good, solid work. The front stringer has a vertical strip 4 inches wide spliced and glued to it so as to receive the winders. The well must be framed wide enough to include, beside the figured width of the stairway, the thickness of the enclosing lining.



FIG. 23.

30. Double Winders.—In Fig. 23 is shown a stairway winding one-quarter turn at the top and bottom, with an 8-inch cylinder, for a continued hand rail. In planning winding stairways, it is important to make the treads as nearly as possible of the same width on the line of travel. This line should be about 14 inches from the face of the stringer, as shown on the plan (*a*). The width between finished walls for this stairway should be at least 6 feet 4 inches, as follows:

Width of stairway from finished wall.....	2 feet 10 inches.
Diameter of cylinder	8 inches.
Hall passage.....	2 feet 10 inches.
	6 feet 4 inches.

The distance from the finished wall to the cylinder is made 3 feet 1 inch, so as to allow room for moving furniture. Where the stairway is continuous, the first and last risers of each flight should be placed 2 inches beyond the landing fascia line, in order to make a proper finish with the fascia.

In commencing the drawing, the starting and landing risers are marked on the plan, and the line of travel divided equally, as before mentioned. Then the space along the cylinder is divided; and lastly, the risers along the straight stringer are drawn in position. Lines are drawn through the points found along the line of travel and passing through the points located along the front stringer, thus completing the plan of the stairway. The elevation (*b*) of the stairway is drawn by projecting the lines of the risers down from the plan, and by drawing the lines of the treads horizontally from the story rod, as shown at tread 10. For the development of the wall stringer, follow the method given in Fig. 22. The headroom, as shown, is 7 feet 6 inches from the top of the third step to the ceiling.

31. Width of Winders.—The winding treads must be made of uniform width around the cylinder, so as to obtain a uniform curve in the rail. It will be observed that there

is a 5-inch width introduced between the straight flight and the cylinder, which provides for a better easement, or ramp, from the pitch of the straight rail into the steeper pitch of the wreath rail; besides, if the winders were all contained in the cylinder, it would make a sudden and abrupt change of inclination in the stairway, causing travelers to stumble and fall.

32. Development of Stringers.—At (c) and (e) in Fig. 23 are shown the methods of developing the front stringer when each end curves around a cylinder. The plan (c) of the front stringer is the same as in (a). The distance ab in (e) is equal to the “layout” of the semicircular cylinder, found as in (d), where de is the *outstretched*, or developed, length of the curve afb . The length of de may be determined as follows: Make ab equal to the diameter of the cylinder; from c , with a radius equal to one-half of ab , describe an arc afb ; from a and b as centers, with a radius equal to ab , describe arcs intersecting in g . From g , through the points a and b , draw lines gd and ge ; through f draw a line tangent to the arc and parallel to ab ; the points where this line intersects with the lines drawn through g , will define the length of de , or the developed length of the arc afb . ACB in (e) is the front stringer, any outstretched step, as C , being obtained by projecting the line of the riser vertically from the plan, and the tread horizontally from the story rod. As the steps D , E , etc., in the cylinder, have their width marked on the plan as $3\frac{1}{4}$ inches, that width is therefore transferred to the development. The stringer in this case is $6\frac{1}{2}$ inches, measured from the angle between the treads and risers. This width is marked out with a compass from each angle, and a pleasing curve is drawn tangent to the arcs, as shown. When a cylinder is of this diameter, or smaller, at the bottom of the flight, the curve of the hand rail presents a better appearance, and it is more convenient when the rail over the regular treads is continued on its pitch into the wreath, without ramping the straight rail. In this case there would

be an easement introduced between the straight rail and the wreath piece.

33. Arrangement of Winders.—In Fig. 24 are shown the plans of two different stairways brought together for comparison, each having one-quarter turn with an 8-inch cylinder and a continued hand rail. It will be seen that by the arrangement shown in (b) a platform is obtained, thus making the flight a much more desirable one. In plan (a)

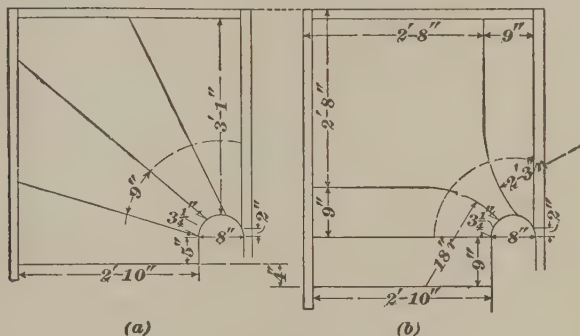


FIG. 24.

there are 4 winders, differing but little from the plan shown in Fig. 23; while in (b) there are 3 winders with slightly curved ends. The 5 risers so changed in their arrangement in (b) take 4 inches more run than the plan with 4 winders as shown. The placing of the carriage timbers in such stairways is a matter requiring care, as the strength and stability of the stairway largely depend thereon.

34. Carriage Timbers.—In Fig. 25 is shown the plan of the top winders of a stairway similar to that in Fig. 23, *a*, *b*, and *c* being the principal timbers in position. The timber *a* is set in place after the stringers are put up, nailed to the floorbeam at *d*, and fastened to the wall at *e*. A piece of furring strip held in the direction *ed*, together with a straightedge tried along the line of the risers, will indicate the best position for this timber.

taken that space has been allowed at all points for the rivet of the plaster which, under stairways, is subjected, at times, to heavy jarring that is likely to loosen the plaster unless it is well keyed or riveted.

NEWEL STAIRWAYS.

35. In Fig. 27 is shown a plan of a quarter-platform open-stringer stairway with 4-inch square newels framed in the angles, the handrails making straight connections with

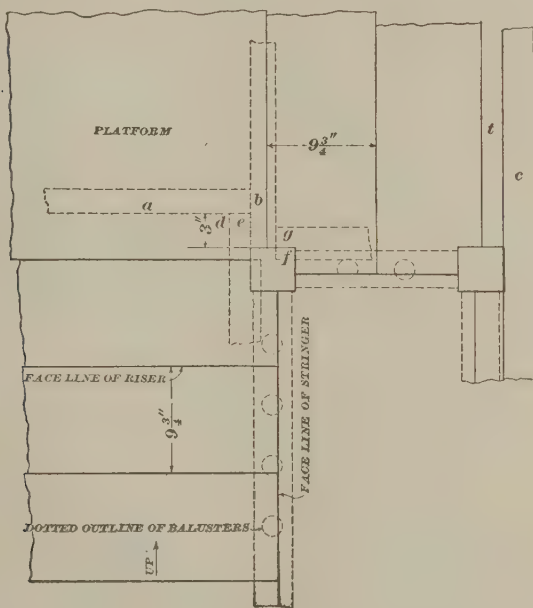


FIG. 27.

the newels, as shown in Fig. 28. The position of the platform beams *a* and *b* and of floorbeam *c* at the landing must be such that a good bearing is secured for the carriage timbers at *d*, *e* and *f*, *g*. The platform beam *b* must be brought forward to give a support of about $\frac{3}{4}$ inch for the newel. The elevation, shown in Fig. 28, is projected from the plan,

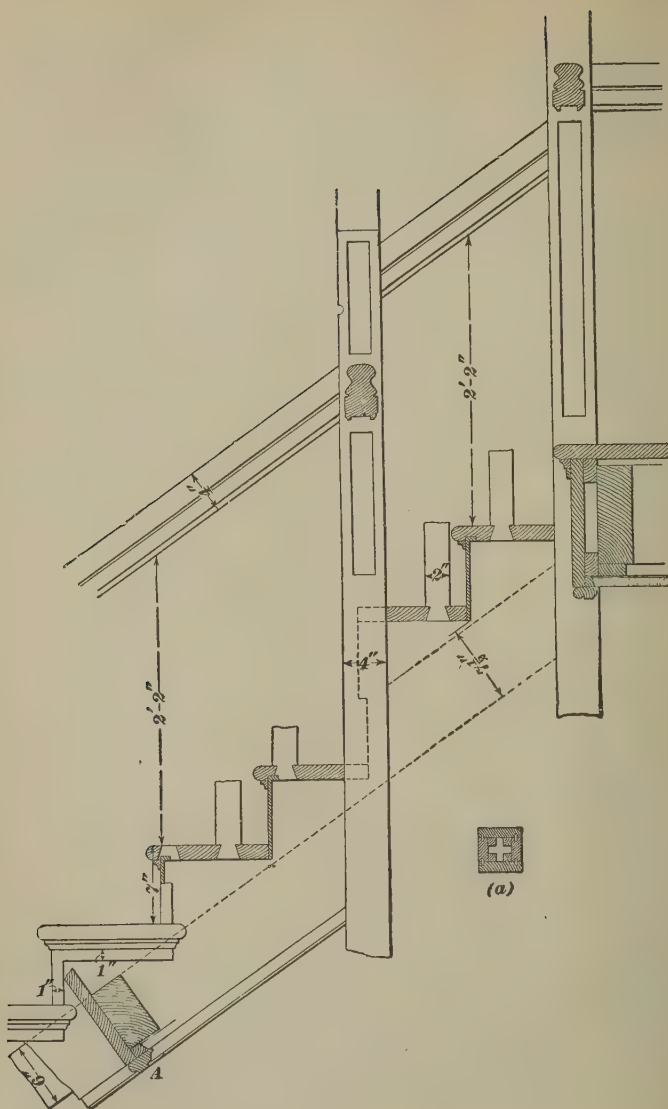


FIG. 28.

and shows the relative position of the newels, hand rails, balusters, and step trim; the latter is composed of $1" \times \frac{1}{4}"$ fillets, nosing, and scotia. The newels are built up as shown at (a) in Fig. 28, slip-tongues being inserted into grooves in the sides, and the whole being properly glued and blocked. The blocks are glued first to the two narrow sides of the newel and when dry are planed square with the edge of these pieces. The whole is then heated in the hot box, and blocks, edges, and slip-tongues are glued and brought together with handscrews.

36. Open Stringers.—In Fig. 29 are shown an elevation and section of an open stringer, where fillets are used. At (a) is a portion of the stringer showing the step trim with fillets *a, a*; the lower portion of the stringer is relieved to

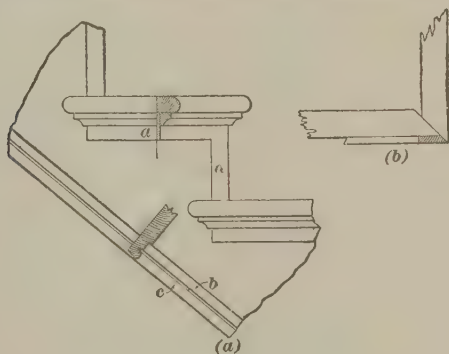


FIG. 29.

form a fascia *b*, and the edge is formed into a quirk bead against which the plaster would finish. This method, although often used, does not give as good a bond for the plaster as does the soffit mold shown at *A* in Fig. 28, in which the edge of the stringer is kept square. At (b), Fig. 29, is represented a section of the fillet, mitering with the riser, which shows that the face stringer requires to be kept back the thickness of the fillet, in order that the latter may miter properly with the riser.

37. Close Stringers.—In Fig. 30 are shown a plan (*a*) and an elevation (*b*) of a quarter-platform stairway with 4 risers in the flight adjacent to the landing, close paneled and molded stringers, 6-inch square newels, $2\frac{1}{2}$ -inch turned and square base balusters, and a $4" \times 4\frac{1}{2}"$ double molded hand rail, with ramp and knee, or *goose neck*, connection with newels. In the plan, *a* and *b* are the principal floor-beams of the platform, and *c* is the top landing floor-beam. In drawing the elevation, the first step is to locate the treads and risers as shown by dotted lines. The balusters may be placed at any distance apart that is desirable on close stringers, as their relation to the treads is not noticed. On the plan is shown their relation with reference to the newels, from which measurements should be taken.

Observe, in the elevation of the lower newel, that there are two risers at right angles to each other at the center of the newel, one riser being from the top step of the lower flight to the platform, and one riser from the platform to the first step of the short flight, as shown at *def*. In this elevation the portion *dhe'h*" is the elevation, or side view, of the short flight, from *d* to *e* on the plan (*a*). A cross-section of the close stringer, showing the panel, timbers, blocking, etc., is shown at *D*, and from this the connections with the newels are lined in as indicated. The section *H* along the floor level is the same as at *D*, but if this should prove at any time to be too high above the floor, the panels may be reduced in width. Panel work of this character may have stiles at newel connections, and muntins at suitable intervals in the long flights and landing facias.

38. Half Newels.—In neweled stairways, the rails should always finish against a half newel at the wall connection, and the lower ends of the half newels may be shown below the soffit. Where half newels are placed on the walls opposite the platform newels, ornamental flat-arch spandrels may be framed between each newel and half newel, thus finishing the soffit of the platform

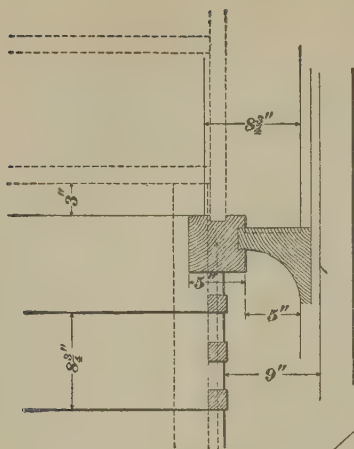


FIG. 31.

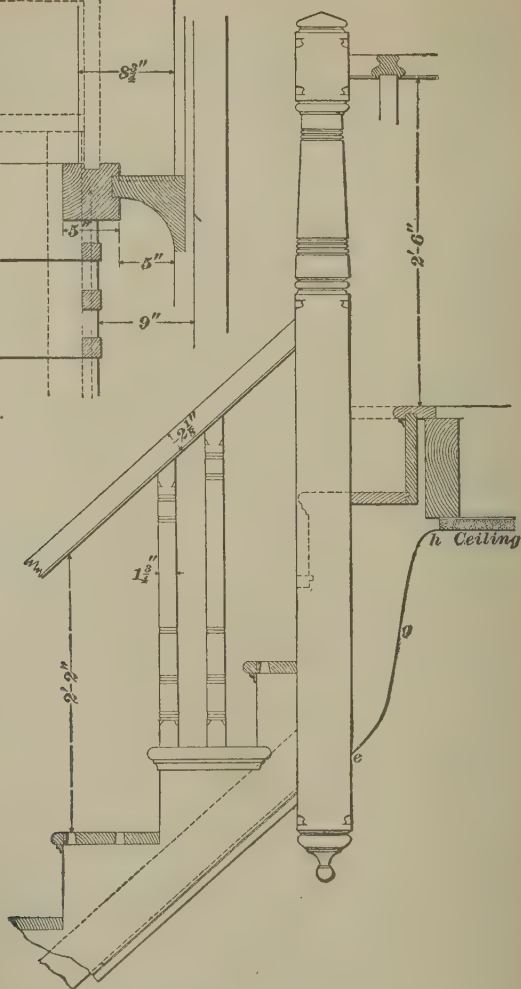


FIG. 32.

39. Newel Posts and Rails.—The length of newel posts is governed by the depth of the stringer, including the soffit molding. Fixing the height of the easement at G , Fig. 30, and the height of the level hand rail at J , the height of the hand rail up the flight is figured, and the rail is made parallel to the line of the stringer. There is nothing important in the position of G , except that it fixes the level of the knee at k .

To produce a good easement, draw the horizontal line li at the required height of the easement and continue the bottom line of the inclined rail until it intersects this horizontal line. Lay off im equal to il and draw mn perpendicular to im . Let mo equal the thickness of the hand rail; from n as a center, describe the easement lines op and ml . For the ramp and knee, make qr from $\frac{1}{2}$ to $1\frac{1}{2}$ inches; perpendicular to qs , draw rv , which is a continuation of il . Draw rt parallel to the newel, and continue the bottom line of rail until it intersects rt ; make tu equal to rt ; from u draw uv at right angles to tu ; make rv equal to the thickness of the rail, and draw wk parallel to qs . With v , the intersection of rv and uv , as a center, describe the arcs ru and wx . The ramp and knee at the upper landing are defined in the same way. The rail may be curved, as indicated by the arc $c'e'$, forming a *goose neck*.

40. Special Arrangement of Newels.—In Figs. 31 and 32 are shown the plan and elevation of a quarter-platform stairway having a quarter-cylinder connection to the landing, thus avoiding the use of a second newel.

41. In Fig. 33 are shown the plan (a), elevation (b), and development (c) of a straight stairway, with a single newel set diagonally at the landing, the stringer facia and hand rail being curved to enter two adjacent faces of the newel. In the plan, $abcd$ is the position of the carriage timber; A and B indicate the position of the floorbeams. Half balusters are set against the sides of the newel to which the hand rails are connected. In the elevation, $a'b'd'c'$ show the depth and position of the carriage timbers, and A is the landing

floorbeam. In the development (c) lay off from the face of the riser, $s'e'$ equal to the corresponding distance on the plan, designated at os ; then lay off $c'h'$ equal to the arc sh on plan; through h' and c' erect perpendiculars for the sides of the newel; through e' draw $e'j$ parallel to the face of the newel; lay off $s''t'$ equal to st in the plan; parallel to $s''j$ draw $t'z$; from the point where this line intersects the

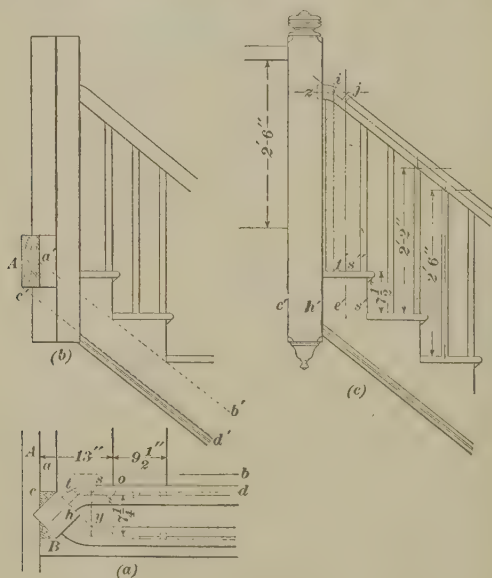


FIG. 33.

center line of the inclined rail draw iz parallel to the tread, then jiz is the center line of the rail. This fixes the height of the flight rail at the newel; the level rail is 2 ft. 6 in. above the floor. The easement curve at the top of the rail is entirely independent of the horizontal curve on the plan, and may be determined by laying off equal tangents on each side of i and erecting perpendiculars to the respective tangents. The point of intersection of these perpendiculars is the center for the easement curve zj .

The horizontal curve on plan is determined by laying off ts equal to th and drawing perpendiculars sy and hy . Then y is the center for the curves of the rail and stringer.

42. Swelled Steps and Curved Stringers.—For a pleasing effect the start of a stairway is often widened by curving the front stringer, and increasing the width of several treads by curving the risers. Fig. 34 shows a plan of such a stairway and a development of the stringer and rail.

To find the height at which the rail enters the newel, draw the bottom line of the rail through the points where the centers of the short balusters would occur, as at dd' ; set off from dd' the thickness of the rail, 2 inches, and draw the center line of the rail ef . The tangents ck and ca are equal, and k is where the rail joins the newel. Make gf equal to mk ; draw co vertically; through o , draw hj at right angles to co . If the rail is brought to a level on

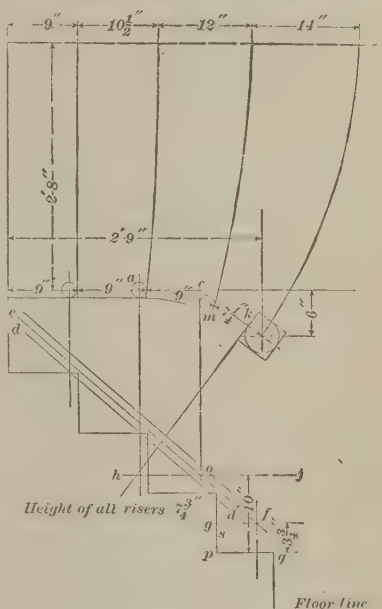


FIG. 34.

oj , its height will be 10 inches above the bottom step pq . In this development the rail is below its real position a distance the height of a short baluster, or 2 feet 2 inches. This distance, added to 10 inches, gives 3 feet as the distance from the first step pq to the center of the rail at hj . If the rail is without an easement to the newel, as at f , its height will be 2 feet $5\frac{3}{4}$ inches.

In Fig. 35 is shown a stairway starting at the newel with a curved stringer and swelled steps; the newel in this arrangement is to stand on the first step, the riser extending

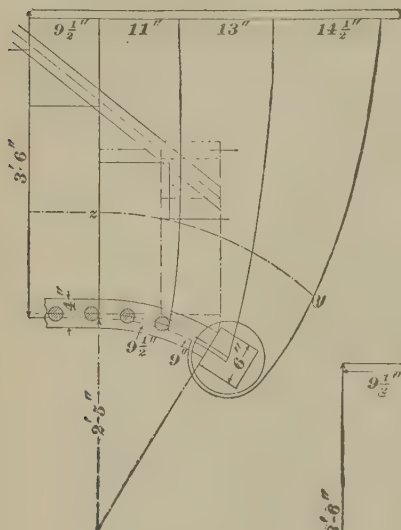


FIG. 35.

around to the stringer which will receive it. Thus the newel does not project beyond the line of the first step, and, where the space is limited, this method will help to overcome the difficulty. The height of the newel in this case may be determined by the

method explained for Fig. 34.

In Fig. 36 is shown a plan wherein the stringer is curved as in the previous examples, but, with the exception of the starting one, the risers are made straight.

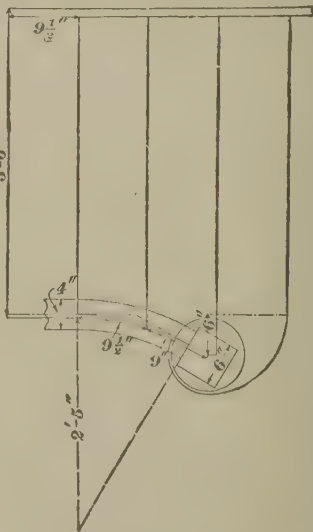


FIG. 36.

43. Curtail Step.—In Fig. 37 is shown a method of describing the curves of a *curtail step*. Begin by drawing a circle of a size greater than that required to enclose the required scroll. Let *abcd* be such a

circle; divide it into 16 equal parts, and let the diameter of the eye of the scroll be equal to ef , in this case 7 inches. The diameter of the eye should always be somewhat greater than the width of the hand rail, which in this case is 6 inches. At right angles to bd , and tangent to the eye, draw $e'i$; from i draw ij , perpendicular to hg ; and so proceed, drawing lines at right angles to the successive radial lines; and continue this process to m , or to any point desired. From the points of intersection m, n , etc., on the radial lines, with

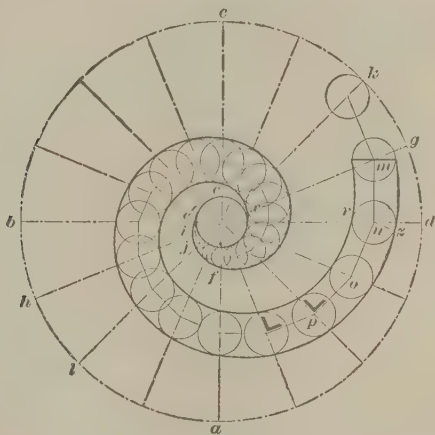


FIG. 32.

a radius equal to 3 inches, or one-half the width of the rail, describe circles as shown until one is tangent to the eye, as at x . From here each successive circle is smaller so as to be tangent to the eye. Tangent to these circles, draw in an outline of the curve of the hand rail.

In Fig. 38 is shown a plan (a) of the curtail step with curved steps receding from same. This plan may be drawn from the dimensions shown, taking as much of the scroll delineated in Fig. 37 as is required to fulfil the conditions. At sr , in Fig. 38, is shown the junction of the scroll with the straight rail. Where the scroll has been developed in a diagram, as shown

in Fig. 37, the whole or any part of it may be transferred to the plan of the stairway, as was done in Fig. 38. In order to fix the height of the wreathed portion of the scroll, draw an elevation of the risers and treads as at (b). Draw the

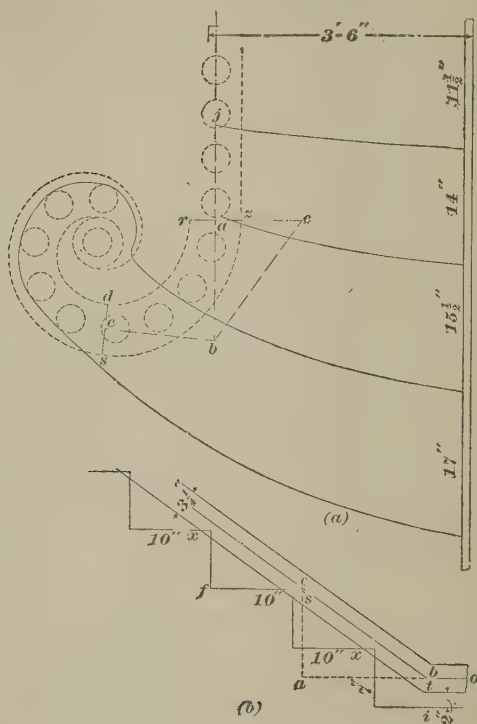


FIG. 38.

bottom line of the rail xx through the points on the treads where the center lines of the short balusters intersect; draw the center line cb of the rail; make fs equal to ja in (a). Parallel to the riser lines, draw ca through s ; make ti equal to, say, 2 inches, thereby fixing the height of the eye and the level portion of the scroll. Make tb equal to one-half the depth of the rail; draw ba parallel to the tread line.

Then, as the bottom line of the scrolled rail is 2 inches above the first step *i*, and the length of a short baluster is 2 feet 2 inches, the height from *i* to *t* will be 2 feet 4 inches, when in position. It is desirable to keep the scrolled rail as low as that shown, so that its varying and pleasing curvature will be seen to the best advantage. In the plan (*a*), *ab* is the center line of the rail prolonged, and *acb* is taken from lines similarly lettered in (*b*). From *b*, draw *be* tangent to the center line of the rail at *c*. The joint *sd* is made at right angles to *eb*. From *sd* to *sr* is the wreathed portion of the rail, since it both curves and rises. The remaining portion of the scroll, from *sd* to the eye, is horizontal, as shown by *bo* in the elevation (*b*), and in this part of the scroll, three or four of

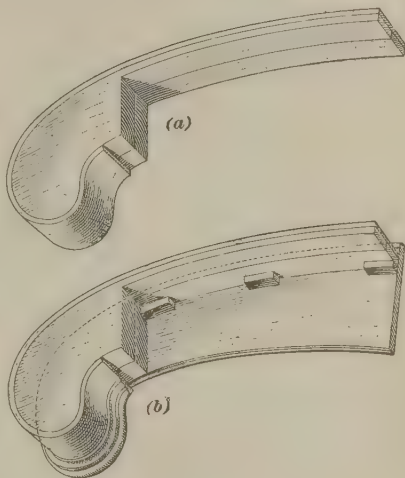


FIG. 39.

the balusters should be bolted to the step at their bases, and to the scrolled rail at their tops. The construction of the veneered riser and scroll block is shown in Fig. 39 (*a*), and the complete scroll step is shown in (*b*).

SPECIAL FORMS OF STAIRWAYS.

44. Quarter Platform.—In Fig. 40 is shown a plan of a quarter-platform stairway with a quarter cylinder for a continued hand rail. Any radius of cylinder considered desirable may be used, but if the risers *ob* and *o'b'* be put at a distance equal to one-half the width of a tread from the

point *a*, the intersection of the center lines of the rail, the wreath piece will conform to the common pitch of the flights. If the front stringer is a close one, and the risers are placed as shown, the effect will be more agreeable than it would be if the risers were placed either nearer to, or farther from, the point *a*. This arrangement of the risers will allow a graceful curve in the development of the front stringer and the hand rail, while if placed in any other position, the result would be an unsightly crippled rail and stringer.

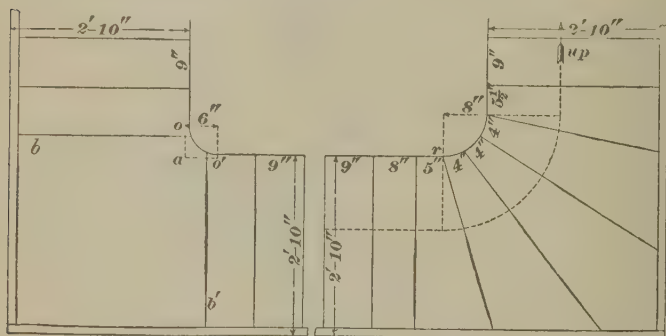


FIG. 40.

FIG. 41.

45. Quarter-Turn Winding.—The plan of a quarter-turn winding stairway, with a quarter cylinder for a continued hand rail, and with regular treads above and below, is shown in Fig. 41. It will be noticed that the treads adjoining the cylinder in both flights are reduced. The benefit derived from the reduction will appear in the curve of the rail and stringer, as it modifies the angle of intersection between the pitch of one straight rail and that over the winders, the stringer, of course, being affected in the same manner.

46. Platform and Curved Risers.—In Fig. 42 is shown a plan of a stairway which includes two platforms with a tread and two curved risers in the 10-inch cylinder between the platforms, making a half turn. The wreathed rail

over this plan has a pleasing shape, and no ramp is required in the straight rail either above or below the wreath.

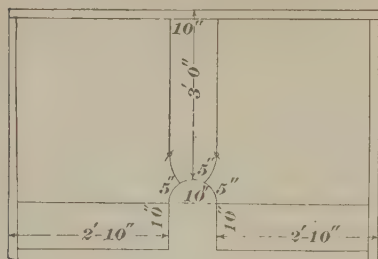


FIG. 42.

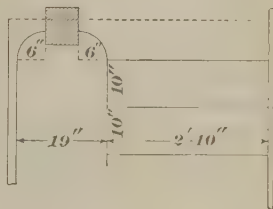


FIG. 43.

47. Newel Between Quarter Cylinders.—Fig. 43 is a plan of a stairway with a newel post set between quarter cylinders on the landing of a flight; the hand rail in this case would be bolted to the newel.

48. Half-Turn Platform.—In Fig. 44 is shown a half-turn platform stairway. The face of the top riser of lower flight and of the bottom riser of upper flight have

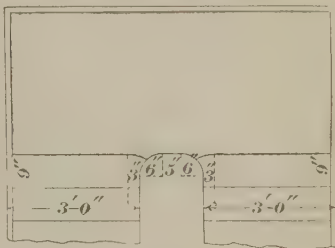


FIG. 44.

a slight curve adjacent to the flattened cylinder. By this method the whole depth of the cylinder is saved in the width of landing—an advantage where space is limited.

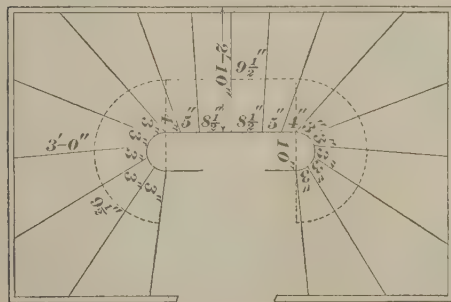


FIG. 45.

49. Winding Stairway.—Fig. 45 is a plan of a winding stairway with 17 risers, and 10-inch cylinders for a continued hand rail. This

arrangement is suitable where space is limited and where the entrance to the staircase is on the side.

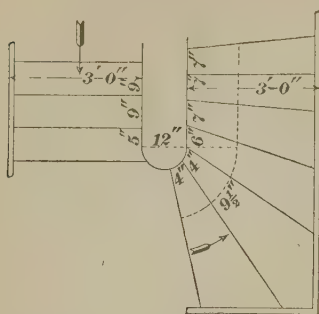


FIG. 46.

50. Arrangement for Intermediate Floor.—Fig. 46 is a plan for the starting and landing of two flights connected by a 12-inch cylinder; such an arrangement is used where the short flight ascends to an intermediate floor on the platform level.

51. Quarter Platform With Tangent Between Quarter Cylinders.—Fig. 47 is a plan of a quarter-platform stairway for a continued hand rail. The cylinder opening of 18 inches is formed by two quarter circles, each of 5 inches radius, and an 8-inch piece of straight stringer between. By this method a platform is secured, and angular winders are dispensed with; the length of the staircase is also reduced.

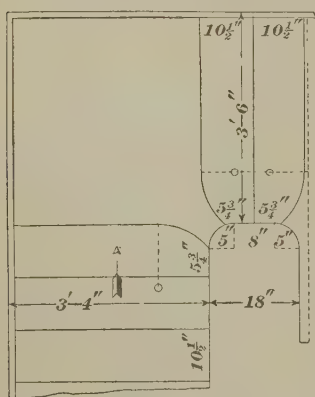


FIG. 47.

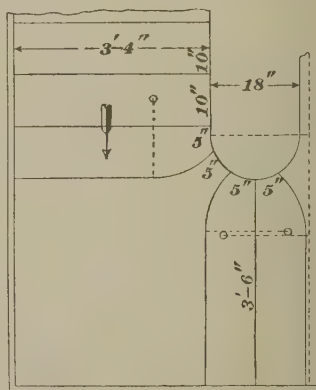


FIG. 48.

52. Quarter Platform With Semicircular Cylinder. Fig. 48 differs from the preceding plan only in the form of its

cylinder, which is semicircular in plan, and, while requiring a little more run, furnishes a more pleasing rail and cylinder.

53. Double Platforms.—Fig. 49 is a plan of a platform stairway making a half turn, one riser at the center of the cylinder dividing the space into two platforms. Where the run will permit, it is always advisable to dispense with this central riser, thus adding breadth to the platform, and avoiding the danger of stumbling at the step placed where it is not expected.

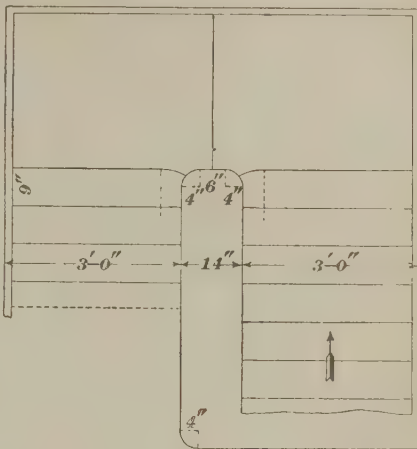


FIG. 49.

54. Quarter Platform With Step.—Fig. 50 is a plan of a quarter-platform stairway with a 15-inch cylinder having a regular step at its center.

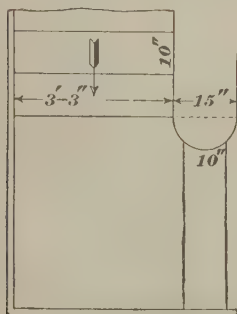


FIG. 50.

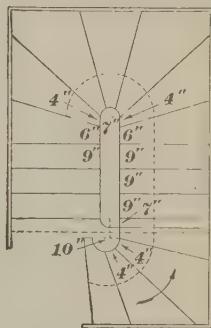


FIG. 51.

55. Three-Quarter Turn.—Fig 51 is a plan of a wind ing stairway making a three-quarter turn, the entrance being at one end of the staircase.

56. Starting or Landing Winders.—Fig. 52 is a plan of a stairway which has winders either at the starting or at the landing. The curving of the risers is resorted to for the purpose of making them occupy less room from *l* to *m*. Curving the risers in this manner also improves the appearance of the stairway, by reducing its angularity.



FIG. 52

57. Quarter Platform With Newels.—

Fig. 53 is a plan of a quarter-platform stairway with small newels framed to the stringers in the angles; the hand rail may join the newels either straight, or with easements and with ramp and knee, or with a goose neck. The curved risers are introduced to save the space in the run of the flights.

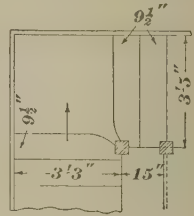


FIG. 53.

58. Platform Stairway With Two Return Flights. Fig. 54 is a plan of a platform stairway with two return,

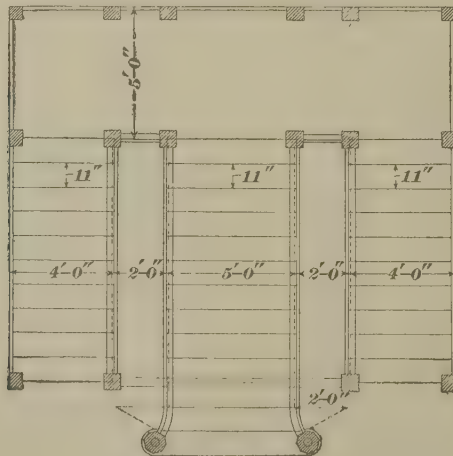


FIG. 54.

or *wing*, flights, suitable for a public building. The flights and platform may be wainscoted, and, by the introduction of half newels set against the wall opposite the regular newels, a good structural effect is obtained. The regular and wall newels may be carried up as columns and pilasters, further improving the treatment. Flat, ornamental arches may be introduced between the newels and half newels where they extend below the soffit of the platform, to break up and panel the soffit spaces. For a public stairway of this character, in either wood or iron, a better effect is produced by omitting the plaster and showing the framework.

59. Circular Stairway. A plan of a circular stairway is shown in Fig. 55; all the risers except the three curved ones at the start radiate from the center *b*, and are equally spaced at the front and wall stringers. The front stringer along the first two steps is curved out, to increase the width of the stairway at the start, thus giving it a more pleasing appearance. A curtail step and hand rail at the starting of such a stairway are very appropriate and attractive. The dotted lines indicate the position of the carriage timbers. A similar method may be followed for elliptic stairways.

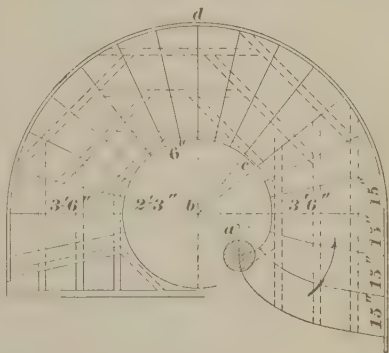


FIG. 55.

Instead of a cylindrical front stringer, as in this plan, a circular newel post of sufficient length is sometimes used as a central support, the treads and risers being framed into the central newel and into the wall stringer. The newel post may be cased with $\frac{7}{8}$ -inch boards of the same width as the treads at the point of connection, affording support and enclosure like mortises, to the steps; the grooves for the risers



FIG. 57.

d, the middle rail; *e*, the top rail; *f*, the cap molding; *g*, the base molding; and *h*, the furring strip. In the elevation, *h' h'* is a stile with a groove *j* to receive the return wainscoting; at *k*, *k* are muntins. The stile *h' h'* extends the whole height, and the three rails are framed into it. The panels are square on the level portion, but up the flight they become lower, as the width of the wainscot *n n* is less than the width *m m*. The curves at the junction of the pitch and level lines are described from three different centers, as shown. The curves cannot be described from a common center, as the two portions are not of the same width. By producing the tangents of the level and inclined portions of the top, bottom, and central rails, and deciding on the length of the curves, radial lines may be drawn from the points, as at *c*, *c*, thus locating the center, from which simple curves may be drawn. At (*a*) is shown a method of fastening the panels whereby no nails show on the face of the molding.

The panels are polished separately, and put in place after the frame and moldings are finished. The framework should be well seasoned, and the walls should be perfectly dry before the wainscoting is set in position.

GEOMETRICAL DRAWING.

INSTRUMENTS AND MATERIALS.

1. A **drawing** is a representation of objects on a plane surface by means of lines or lines and shades. When done by the use of free hand only, it is called **freehand drawing** or **sketching**; when instruments are used, so that greater exactness may be obtained, it is called **instrumental, or mechanical, drawing**.

2. All of the instruments and materials required for the courses in drawing are mentioned in the following descriptions:

The **drawing board** should be made of well-seasoned, straight-grained pine, the grain running lengthwise. For this course, the student will need a board of the following dimensions: length over all, $22\frac{1}{2}$ inches; width, $16\frac{1}{2}$ inches.

The drawing board illustrated in Fig. 1 is the one furnished in our students' drawing outfits and can be fully recommended as possessing the qualities a good and accurate board should have. It is made of several pieces of pine wood glued together to the required width of the board. A pair of hardwood cleats is screwed to the back of the board, the screws passing through the cleats in oblong slots with iron bushings, which allow the screws to move freely when drawn by the contraction and expansion of the board. Grooves are cut through half the thickness of the board over the entire back side. These grooves take the transverse resistance out of

the wood and allow it to be controlled by the cleats, at the same time leaving the longitudinal strength nearly unimpaired. In order to provide a perfectly smooth working

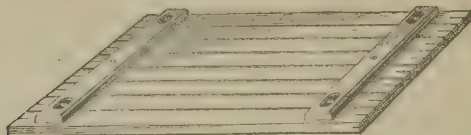


FIG. 1.

edge, for the head of the **T** square to slide against, a strip of hard wood is let into the short edges of the board, and is sawed through in several places, in order to allow for the contraction and expansion of the board. The cleats also raise the board from the table, thus making it easier to

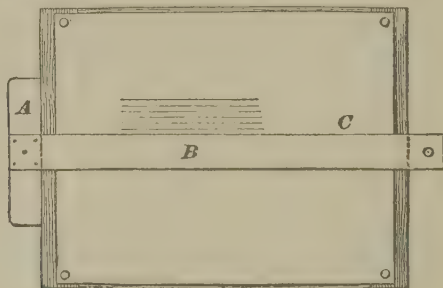


FIG. 2.

change the position of the board. When in use the board is placed so that one of the short edges is at the left of the draftsman, as shown in Fig. 2.

3. The **T** square is used for drawing horizontal straight lines. The head *A* is placed against the left-hand edge of the board, as shown in Fig. 2. The upper edge *C* of the blade *B* is brought very near to the point through which it is desired to pass a line, so that the straight edge *C* of the blade may be used as a guide for the pen or pencil. It is evident that all lines drawn in this manner will be parallel.

Vertical lines are drawn by means of triangles. The triangles most generally used are shown in Figs. 3 and 4, each of which has one right angle. The triangle shown in Fig. 3

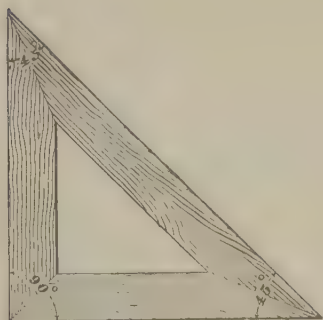


FIG. 3.



FIG. 4.

has two angles of 45° each, and that in Fig. 4 one of 60° and one of 30° . They are called 45° and 60° triangles, respectively. To draw a vertical line, place the T square in position

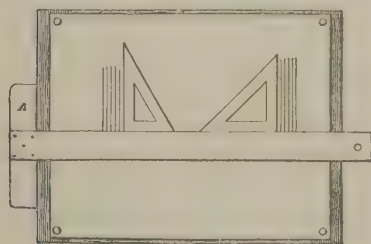


FIG. 5.

to draw a horizontal line, and lay the triangle against it, so as to form a right angle. Hold both T square and triangle lightly with the left hand, so as to keep them from slipping, and draw the line with the pen or pencil held in the right hand, and

against the edge of the triangle. Fig. 5 shows the triangles and T square in position.

4. For drawing parallel lines that are neither vertical nor horizontal, the simplest and best way, when the lines are near together, is to place one edge of a triangle, as ab , Fig. 6, on the given line cd , and lay the other triangle, as B ,

against one of the two edges, holding it fast with the left hand; then move the triangle *A* along the edge of *B*. The edge *ab* will be parallel to the line *cd*; and when the edge *ab* reaches the point *g*, through which it is desired to draw the parallel line, hold both triangles stationary with the left

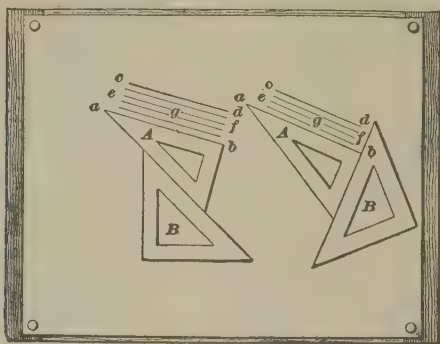


FIG. 6.

hand, and draw the line *ef* by passing the pencil along the edge *ab*. Should the triangle *A* extend too far beyond the edge of the triangle *B* after a number of lines have been drawn, hold *A* stationary with the left hand and shift *B* along the edge of *A* with the right hand, and then proceed as before.

5. A line may be drawn at right angles to another line which is neither vertical nor horizontal, as illustrated in Fig. 7. Let *cd* be the given line (shown at the left-hand side). Place one of the shorter edges, as *ab*, of the triangle *B* so that it will coincide with the line *cd*; then, keeping the triangle in this position, place the triangle *A* so that its long edge will come against the long edge of *B*. Now, holding *A* securely in place with the left hand, slide *B* along the edge of *A* with the right hand, when the lines *hi*, *mn*, etc. may be drawn perpendicular to *cd* along the edge *bf* of the triangle *B*. The dotted lines show the position of the triangle *B* when moved along the edge of *A*.

6. The right-hand portion of Fig. 7 shows another method of accomplishing the same result, and illustrates how the triangles may be used for drawing a rectangular figure, when the sides of the figure make an angle with the T square such that the latter cannot be used.

Let the side cd of the figure be given. Place the *long* side of the triangle B so as to coincide with the line cd , and bring the triangle A into position against the lower side of B , as shown. Now, holding the triangle A in place with the left hand, revolve B so that its other

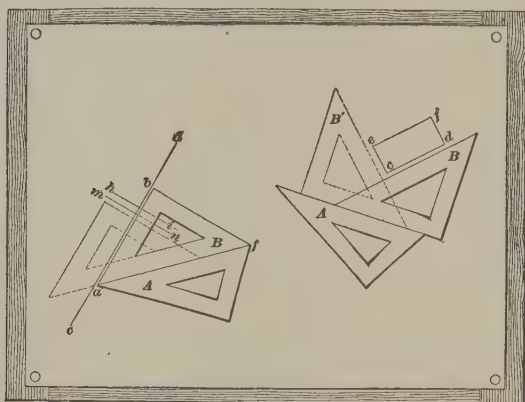


FIG. 7.

short edge will rest against the long edge of A , as shown in the dotted position at B' . The parallel lines ce and df may now be drawn through the points c and d by sliding the triangle B on the triangle A , as described in connection with Fig. 6. Measure off the required width of the figure on the line ce , reverse the triangle B again to its original position, still holding the triangle A in a fixed position with the left hand, and slide B upon A until the long edge of B passes through e . Draw the line ef through the point e , and ef will be parallel to cd . The student should practice with his triangles before beginning drawing.

7. The **compasses**, next to the **T square** and triangles, are used more than any other instrument. A pencil and pen point are provided, as shown in Fig. 8, either of which may be inserted into a socket in one leg of the instrument, for the drawing of circles in pencil or ink. The other leg is fitted with a needle point, which acts as the center about which the circle is drawn. In all good instruments, the

needle point itself is a separate piece of round steel wire, held in place in a socket provided at the end of the leg. The wire should have a square shoulder at its lower end, below which a fine, needle-like point projects. The *lengthening bar*, also shown in the figure, is used to extend the leg carrying the pen and the pencil points when circles of large radii are to be drawn.

The joint at the top of the compasses should hold the legs firmly in any position, and at the same time should permit their being opened or closed with one hand. The joint may be tightened or loosened by means of a screwdriver or wrench, which accompanies the compasses.

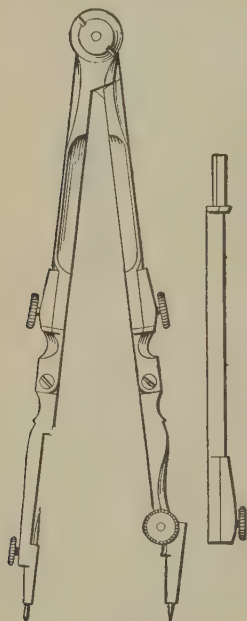


FIG. 8.

It will be noticed in Fig. 8 that each leg of the compasses is jointed; this is done so that the compass points may always be kept perpendicular to the paper when drawing circles, as in Fig. 11.

The style of compasses shown in Fig. 8 have what is called a *tongue joint*, in which the head of one leg has a tongue, generally of steel, which moves between two lugs on the other leg. Another common style of joint is the

pivot joint in which the head of each leg is shaped like a disk and the two disks are held together in a fork-shaped brace either by means of two pivot screws or by one screw penetrating both disks. The brace that forms a part of this



FIG. 9.

joint is generally provided with a handle, as the shape of the joint makes it rather awkward to hold the compasses by the head as is usual with instruments provided with tongue joints. In Fig. 9 is shown a common style of pivot joint.

8. The following suggestions for handling the compasses should be carefully observed by those who are beginning the subject of mechanical drawing. Any draftsman who handles his instruments awkwardly will create a bad impression, no matter how good a workman he may be. The tendency of

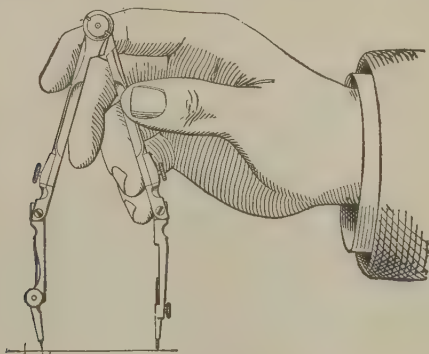


FIG. 10.

all beginners is to use both hands for operating the compasses. This is to be avoided. The student should learn at the start to open and close them with one hand, holding them as shown in Fig. 10, with the needle-point leg resting

between the thumb and fourth finger, and the other leg between the middle and forefinger. When drawing circles, hold the compasses lightly at the top between the thumb and forefinger, or thumb, forefinger, and middle finger, as in Fig. 11. Another case where both hands should not be used is in locating the needle point at a point on the drawing about which the circle is to be drawn, unless the left hand is used merely to steady the needle point.

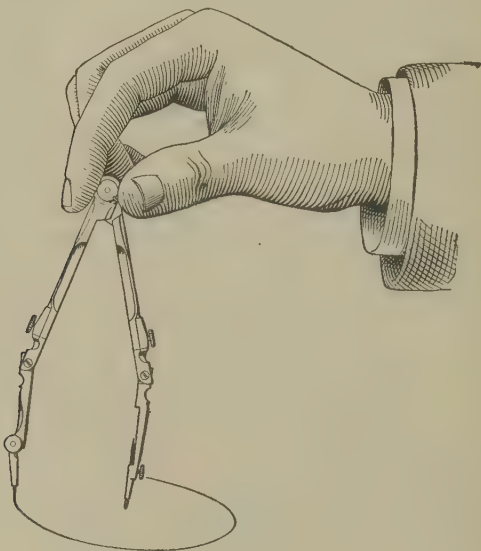


FIG. 11.

Hold the compasses as shown in Fig. 10, and incline them until the under side of the hand rests upon the paper. This will steady the hand so that the needle point can be brought to exactly the right place on the drawing. Having placed the needle at the desired point, and with it still resting on the paper, the pen or pencil point may be moved out or in to any desired radius, as indicated in Fig. 10. When the lengthening bar is used, both hands must be employed.

9. The compasses must be handled in such a manner that the needle point will not dig large holes in the paper. Keep the needle point adjusted so that it will be perpendicular to the paper, when drawing circles, and *do not bear upon it*. A slight pressure will be necessary on the pen or pencil point, *but not on the needle point*.

10. The dividers, shown in Figs. 9 and 12, are used for laying off distances upon a drawing, or for dividing straight lines or circles into parts. The points of the dividers should be *very* sharp, so that they will not punch holes in the paper larger than is absolutely necessary to be seen. Compasses are sometimes furnished with two steel divider points, besides the pen and pencil points, so that the instrument may be used either as compasses or dividers. This is the kind illustrated in Fig. 12. When using the dividers to

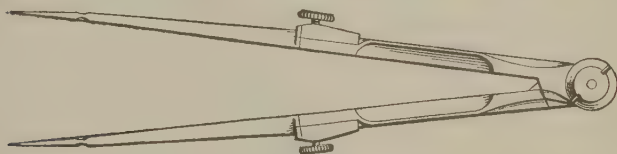


FIG. 12.

space a line or circle into a number of equal parts, hold them at the top between the thumb and forefinger, as when using the compasses, and step off the spaces, turning the instrument alternately to the right and left. If the line or circle does not space exactly, vary the distance between the divider points and try again; so continue until it is spaced equally. When spacing in this manner, great care must be exercised not to press the divider points into the paper; for, if the points enter the paper, the spacing can never be accurately done. The student should satisfy himself of the truth of this statement by actual trial.

11. The bow-pencil and bow-pen, shown in Fig. 13, are convenient for describing small circles. The two points of the instruments must be adjusted to the same length;

otherwise, very small circles cannot be drawn. To open or close either of these instruments, support it in a vertical position

by resting the needle point on the paper and bearing slightly on the top of it with the forefinger of one hand, and turn the adjusting nut with the thumb and middle finger of the same hand.

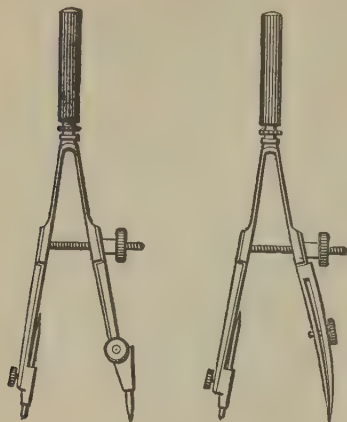


FIG. 13.

12. Drawing Paper and Pencils.—The drawing paper recommended for this series of lessons is the T. S. Co.'s cold-pressed demy, the size of which is 15" × 20". It takes ink

well, and withstands considerable erasing. The paper is secured to the drawing board by means of **thumbtacks**.

Four are usually sufficient—one at each corner of the sheet (see Fig. 7). Place a piece of paper on the drawing board, and press a thumbtack through one of the corners about $\frac{1}{4}$ or $\frac{3}{8}$ of an inch from each edge. Place the **T** square in position for drawing a horizontal line, as before explained, and straighten the paper so that its upper edge will be parallel to the edge of the **T** square blade. Pull the corner diagonally opposite that in which the thumbtack was placed, so as to stretch the paper slightly, and push in another thumbtack. Do the same with the remaining two corners. For drawing in pencil, an HHHH pencil of any reputable make should be used.

The pencil should be sharpened as shown at *A*, Fig. 14.



FIG. 14.

Cut the wood away so as to leave about $\frac{1}{4}$ or $\frac{3}{8}$ of an inch of the lead projecting; then sharpen it flat by rubbing it against a fine file or a piece of fine emery cloth or sandpaper that has been fastened to a flat stick. Grind it to a sharp edge like a knife blade, and round the corners very slightly, as shown in the figure. If sharpened to a round point, as shown at *B*, the point will wear away very quickly and make broad lines; when so sharpened it is difficult to draw a line exactly through a point. The lead for the compasses should be sharpened in the same manner as the pencil, but should have its width narrower. *Be sure that the compass lead is so secured that, when circles are struck in either direction, but one line will be drawn with the same radius and center.*

13. Inking.—For drawing ink lines other than arcs of circles, the **ruling pen** (or *right-line pen*, as it is sometimes called) is used. It should be held as nearly perpen-

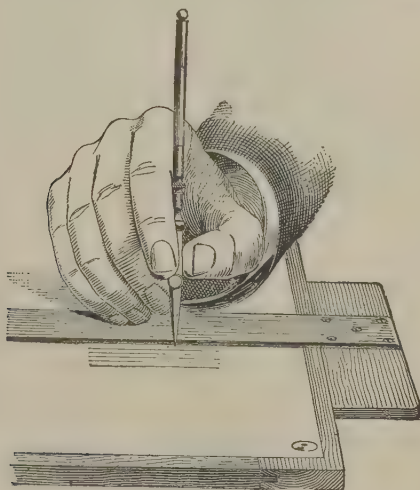


FIG. 15.

dicular to the board as possible, with the hand in the position shown in Figs. 15 and 16, bearing lightly against the **T** square

or triangle, along the edge of which the line is drawn. After a little practice, this position will become natural, and no difficulty will be experienced.

14. The beginner will find that it is not always easy to make smooth lines. If the pen is held so that only one blade bears on the paper when drawing, the line will almost invariably be ragged on the edge where the blade does not bear. When held at right angles to the paper, as in Fig. 16, how-

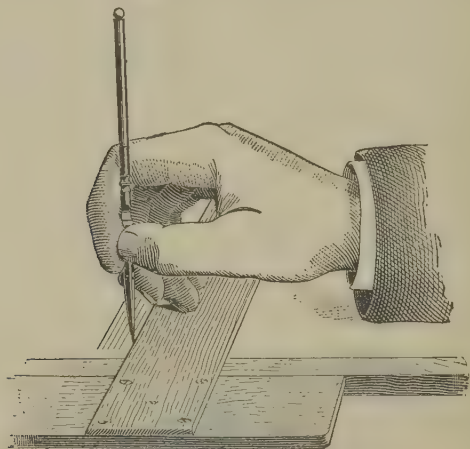


FIG. 16.

ever, both blades will rest on the paper, and if the pen is in good condition, smooth lines will result. The pen must not be pressed against the edge of the T square or triangle, as the blades will then close together, making the line uneven. The edge should serve as a guide, simply.

In drawing circles with the compass pen, the same care should be taken to keep the blades perpendicular to the paper by means of the adjustment at the joint. In both the ruling pen and compass pen, the width of the lines can be altered by means of the screw which holds the blades together. The handles of most ruling pens can be unscrewed and are provided with a needle point intended for use

when copying maps by pricking through the original and the underlying paper, thus locating a series of points through which the outline may be drawn.

15. Drawing Ink.—The ink we recommend for the work in this course is the T. S. Co.'s superior waterproof liquid India ink. A quill is attached to the cork of every bottle of this ink, by means of which the pen may be filled. Dip the quill into the ink, and then pass the end of it between the blades of the drawing pen. Do not put too much ink in the pen, not more than enough to fill it for a quarter of an inch along the blades, otherwise the ink is liable to drop. Many draftsmen prefer to use stick India ink; and, for some purposes, this is to be preferred to the prepared liquid ink recommended above. In case the stick ink is bought, put enough water in a shallow dish (a common individual butter plate will do) to make enough ink for the drawing, then place one end of the stick in the water, and grind by giving the stick a circular motion. Do not bear hard upon the stick. Test the ink occasionally to see if it is black. Draw a fine line with the pen, and hold the paper in a strong light. If it shows brown (or gray), grind a while longer, and test again. Keep grinding until a fine line shows *black*, which will usually take from fifteen minutes to half an hour, depending upon the quantity of water used. The ink should always be kept well covered with a flat plate of some kind, to keep out the dust and prevent evaporation. The drawing pen may be filled by dipping an ordinary writing pen into the ink and drawing it through the blades, as previously described when using the quill. If liquid ink is used, all the lines on all the drawings will be of the same color, and no time will be lost in grinding. If stick ink is used, it is poor economy to buy a cheap stick. A small stick of the best quality, costing, say, a dollar, will last as long, perhaps, as five dollars' worth of liquid ink. The only reason for using liquid ink is that all lines are then sure to be of equal blackness, and time is saved in grinding.

India ink will dry quickly on the drawing, which is

desirable, but it also causes trouble by drying between the blades and refusing to flow, especially when drawing fine lines. *The only remedy is to wipe out the pen frequently with a cloth.* Do not lay the pen down for any great length of time when it contains ink; wipe it out first. The ink may sometimes be started by moistening the end of the finger and touching it to the point, or by drawing a slip of paper between the ends of the blade. *Always keep the bottle corked.*

16. To Sharpen the Drawing Pen.—When the ruling, or compass, pen becomes badly worn, it must be sharpened. For this purpose a fine oilstone should be used. If an oilstone is to be purchased, a small, flat, close-grained stone should be obtained, those having a triangular section being preferable, as the narrow edge can be used on the inside of the blades in case the latter are not made to swing apart so as to permit the use of a thicker edge.

The first step in sharpening is to screw the blades together, and, holding the pen perpendicular to the oilstone, to draw it back and forth over the stone, changing the slope of the pen from downward and to the right to downward and to the left for each movement of the pen to the right and left. The object of this is to bring the blades to exactly the same length and shape, and to round them nicely at the point.

This process, of course, makes the edges even duller than before. To sharpen, separate the points by means of the screw, and rub one of the blades to and from the operator in a straight line, giving the pen a slight twisting motion at the same time, and holding it at an angle of about 15° with the face of the stone. Repeat the process for the other blade. To be in good condition the edges should be fairly sharp and smooth, but not sharp enough to cut the paper. *All the sharpening must be done on the outside of the blades.* The inside of the blades should be rubbed on the stone only enough to remove any burr that may have been formed. Anything more than this will be likely to injure the pen. The whole operation must be done very carefully,

bearing on lightly, as it is easy to spoil a pen in the process. Examine the points frequently, and keep at work until the pen will draw both *fine* lines and *smooth* heavy lines. Many draftsmen prefer to send the pens to be sharpened to the dealer who sold them and who is generally willing to do such sharpening at a trifling cost.

17. Irregular Curves.—Curves other than arcs of circles are drawn with the pencil or ruling pen by means of curved or irregular-shaped rulers, called **irregular curves** (see Fig. 17). A series of points is first determined through which the curved line is to pass. The line is then drawn through these points by using such parts of the irregular curve as will pass through several of the points at once, the curve being shifted from time to time as required.

It is usually difficult to draw a smooth, continuous curve. The tendency is to make it curve out too much between the points, thus giving it a wavy appearance, or else to cause it to change its direction abruptly where the different lines join, making angles at these points. These defects may largely be avoided by always fitting the curve to at least three points, and, when moving it to a new position, by setting it so that it will coincide with part of the line already drawn. It will be found to be a great help if the line be first sketched in freehand, in pencil. It can then be penciled over neatly, or inked, without much difficulty, with the aid of the irregular curve, since the original pencil line will show the general direction in which the curve should be drawn. Whenever the given points are far apart, or fall in such positions that the irregular curve cannot always be made to pass through three of them, the line must invariably be sketched in at first.



FIG. 17.

As an example, let it be required to draw a curved line through the points a, b, c, d , etc., Fig. 18. As just stated, a part of the irregular curve must be used which will pass through at least three points. With the curve set in the first position A , its edge is found to coincide with four points a, b, c , and d . The line may then be drawn from a around to d , or, better, to a point between c and d , since, by not con-

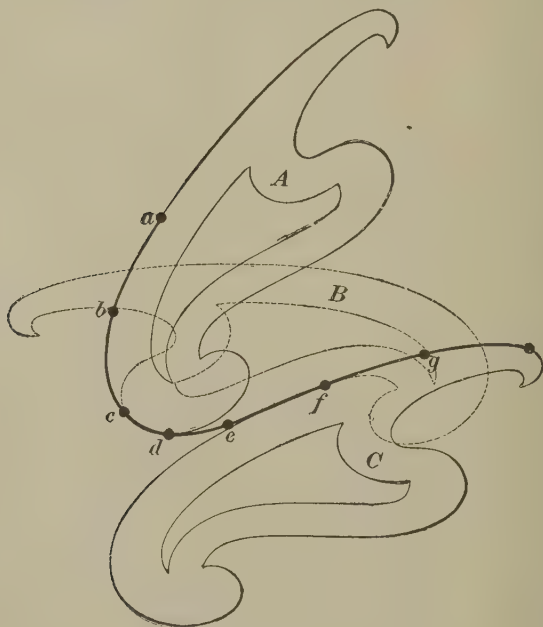


FIG. 18.

tinuing it quite to d , there is less liability of there being an angle where the next section joins on. For the next section of the line, the curve should be adjusted so as to coincide with a part of the section already drawn; that is, instead of adjusting it to points d, e, f , etc., it should be placed so as to pass through the point c , the part from c to d being coincident with the corresponding part of the first line drawn.

The irregular curve is shown dotted in this position at *B*. Its edge passes through four points *c*, *d*, *e*, and *f*, and the line should be made to stop midway between the last two, as before.

Now, it will be noticed that the points *f* and *g* are so situated that the remainder of the line must curve up, instead of down, as heretofore, the change in curvature occurring at a point between *e* and *f*. In this case, therefore, it is not necessary for the curve to extend back to *e*, through which point the line has already been drawn, but it may be placed in position *C* with its edge just tangent to the line at the point where the curvature changes.

It is to be noticed that in inking with the irregular curve, the blades of the pen must be kept tangent to its edge (i. e., the inside flat surface of the blades must have the same direction as the curve at the point where the pen touches the paper), which requires that the direction of the pen be continually changed.

18. The scale is used for obtaining measurements for drawings. The most convenient forms are the usual flat and triangular boxwood scales, having beveled edges, each of which is graduated for a distance of 12 inches. The beveled edges serve to bring the lines of division close to the paper when the scale is lying flat, so that the drawing may be accurately measured, or distances laid off correctly. The use of the graduations on scales will be explained when it is necessary to use the scale.

19. A **protractor** is shown in Fig. 19. The outer edge is a semicircle, with center at *O*, and is divided into 360 parts. Each division is one-half of one degree, and, for convenience, the degrees are numbered from 0° to 180° from both *A* and *B*. The protractor is used for laying off or measuring angles. Protractors are often made of metal, in which case the central part is cut away to make the drawing under it visible. When using the protractor, it must be placed so that the line *OB*, Fig. 19, will coincide with the

line forming one side of the angle to be laid off or measured, and the center O must be at the vertex of the angle.

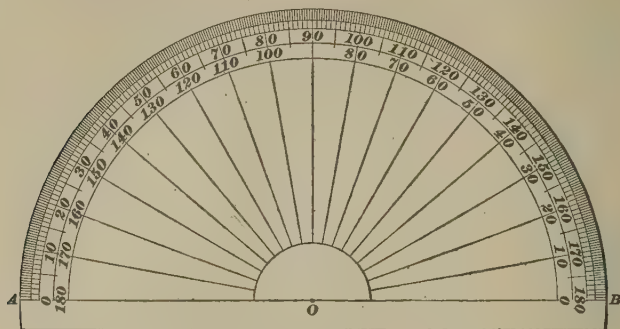


FIG. 19.

For example, let it be required to draw a line through the point C , making an angle of 54° with the line EF , Fig. 20. Place the protractor upon the line EF , as just described, with the center O upon the point C . With a sharp-pointed pencil, make a mark on the paper at the 54° division, as indicated at D . A line drawn through C and D will then make an angle of 54° with EF . Greater exactness will be secured

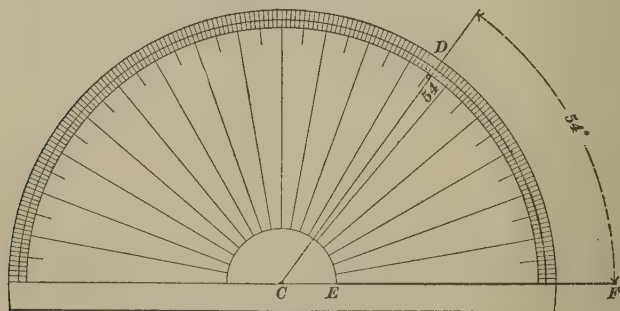


FIG. 20.

if the line EF be extended to the left, so that both zero marks (A and B , Fig. 19) can be placed on the line. This should always be done when possible.

LETTERING.

20. In mechanical drawing, all headings, explanatory matter, and dimensions should be neatly printed on the drawing. Ordinary script writing is not permissible.

It is usually difficult for beginners to letter well, and unless the student is skilful at it, he should devote some time to practicing lettering before commencing the drawing. In correcting the plates, the lettering will be considered as well as the drawing. Many students think that it is only necessary to exercise special care when drawing the views on a plate, and that it is not necessary to take particular pains in lettering. This, however, is not the case, for, no matter how well the views may be drawn, if the lettering is poorly done, the finished drawing will not have a neat appearance. In fact, generally speaking, more time is required to make well-executed letters than to make well-executed drawings of objects. We earnestly request the student to practice lettering, and not to think that that part of the work is of no importance. The student should not be too hasty in doing the lettering. It takes an experienced draftsman considerable time to do good lettering, and no draftsman can perform this work as quickly as he can ordinary writing; therefore, no beginner should attempt to do what experienced draftsmen cannot do. In order to letter well, the work must be done slowly. Very frequently more time is spent in lettering a drawing than in inking in the objects represented. Instructions will be given in two styles of freehand lettering, both extensively used in American drafting rooms.

With the exception of the large headings or titles of the plates, the style and size of all lettering used on the original

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz &
1234567890 1234567890 2'-6 1/4" dia. Cast Iron

FIG. 21.

drawing plates of this course are shown in Fig. 21. This style, although a little more elaborate and difficult in execution, was selected on account of its greater neatness and

legibility. The two styles are very similar in the formation of the letters, and although the student is advised to select and use only one of the two on his drawings in this course, he will find, after having mastered one of the styles, little difficulty in practicing the other.

When lettering, a Gillott's No. 303 pen should be used. The height of the capital letters should be $\frac{3}{8}$ " , and of the small letters two-thirds of this, or $\frac{1}{16}$ " . This applies to both styles of freehand lettering. *Do not make them larger than this.*

21. Before beginning to letter, horizontal guide lines should be drawn with the T square, to serve as a guide for the tops and bottoms of the letters (see Fig. 22). The outside lines should be $\frac{3}{8}$ " apart for the capitals, and the two lower lines $\frac{1}{16}$ " apart for the small letters. The letters should be made to extend fully up to the top and down to the bottom guide lines. They must not fall short of the guide lines, nor extend beyond them.

Mechanical Mechanical

FIG. 22.

Failure to observe this point will cause the lettering to look ragged, as in the second word in Fig. 22.

22. It is very important that all the letters have the same inclination. For example, by referring to Fig. 23 (a), it will be seen that the backs of letters like *B, E, l, g, d, i, t*, etc. are parallel and slant the same way. This is also true of both sides of letters like *H, M, n, u, h, y*, etc.

BEldit HMinuty

FIG. 23 (a).

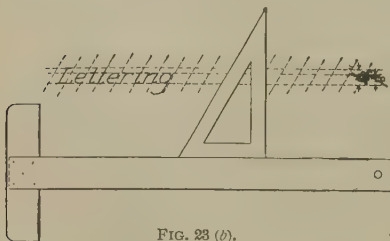


FIG. 23 (b).

as in Fig. 23 (b), and, in lettering, make the backs or sides of the letters parallel with these lines.

23. A few points regarding the construction of the letters are illustrated in Fig. 24, in which the letters are shown upon an enlarged scale. The capital letters *A*, *V*, *Y*, *M*, and *W* must be printed so that their general inclination will be the same as for the other letters. To print the *A*, draw the center line *ad*, having the common slant; from

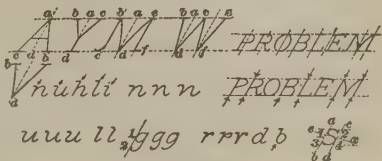


FIG. 24.

a draw the sides *ac* and *ab*, so that points *c* and *b* will each be $\frac{3}{8}$ " distant from point *d*. The side *ab* will be nearly perpendicular to the guide lines. The *V* is like an inverted *A*, and is drawn in the same way, the line *bd* being nearly perpendicular.

To make the *Y*, draw the center line *ad*, having the common slant, which gives the slant for the base of the letter. The upper part of the *Y* begins a little below its center, and is similar to the *V*, though somewhat narrower, as the letter should be only $\frac{5}{8}$ " wide at the top. Points *b* and *c* should be at equal distances from point *a*.

The two sides *bc* and *ef* of the *M* are parallel, and have the common slant. The *M* is made as broad as it is high, or $\frac{3}{2}$ ". Having drawn the two sides, mark the point *d*, midway between the points *c* and *f*, and connect it with points *b* and *e*. The lines *bd* and *cd* should be slightly curved, as shown.

In the *W* the two outside lines are not parallel, as in the *M*, but are farther apart at the top than at the bottom. Draw the line *ad*, having the common slant. Mark points *b* and *c*, which are exactly $\frac{1}{2}$ " from the point *a*. From *b* and *c* draw lines *bd* and *cd*. The other half of the *W* is like the first part, *cf* being parallel to *bd* and *ef* parallel to *cd*. It will be seen that the *W* is composed of two narrow *V*'s, each $\frac{1}{8}$ " wide, the width of the whole letter being $\frac{1}{4}$ ".

24. Capital letters like *P*, *R*, *B*, *L*, *E*, etc. should be printed so that their top and bottom lines will be *exactly*

horizontal. This is illustrated in the two examples of the word *problem* in Fig. 24. In the first example, it will be noticed that the tops of the *P* and *R*, the bottom of the *L*, and the tops and bottoms of the *B* and *E*, all run in the same direction as the guide lines, and coincide with them. In the second example, these lines are not horizontal, which makes the word look very uneven. It is also to be noticed that these lines extend beyond the upright lines in the first word, and that cross-lines are used on the bottom of the *P* and *R*, on the top of the *L*, and on the *M*. In the second word, these lines are omitted at the points indicated by the arrows. These features are found on most of the other capitals.

The small letters *n*, *u*, *h*, *l*, *i*, etc. should have sharp corners at the points indicated by the arrows in Fig. 24. They look much better that way, and are less difficult to make, than when they have round corners. Following these letters are five groups of letters containing *n*, *u*, *l*, *g*, and *r*. The first letter of each group is printed correctly, while the letters following show ways in which they should *not* be printed. In the case of the *g*, point 2 should fall in a slanting direction under point 1, the slant being the same as *a d* of the preceding letters. The difference between *d* and *b* and the construction of the *s* are also shown in the same figure. The *b* should be made rounding at the point indicated. As a guide in making the *s*, draw the two lines *a b* and *c d*, having the common slant. The *s* should now be drawn so that it will touch these lines at points 1, 3, and 4, but *not* at point 2. It will be an additional help if the line *e x* is also drawn as a guide for the middle portion of the *s*; but care should be taken not to have it slant more than shown in the copy.

The letters *a*, *o*, *b*, *g*, etc. should be full and round; do not cramp them. It will be necessary to follow the copy closely until familiar with it. Notice that the figures are not made as in writing, particularly the 6, 4, 8, and 9 (see Fig. 21). Try to space the letters evenly. Letter in pencil first, and, if not right, erase and try again.

25. Another style of freehand lettering is shown in Fig. 25. This style is extensively used for the lettering of working drawings. It is more easily and rapidly

ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijklmnopqrstuvwxyz &

12345678910 1234567890 2"-6¼" dia. Cast Iron.

FIG. 25.

made than the style previously described, and although not productive of as high degree of neatness in appearance will be found very useful and acceptable for general office work.

A comparison between the two systems will disclose a great similarity in the detail formation of the letters.

26. The horizontal and slanting guide lines are drawn exactly in the same manner as for the style previously described, and if

Horizontal Horizontal

FIG. 26.

not followed the results will be similar. See the uneven appearance of the second word in Fig. 26.

27. By studying the formation of the letters carefully, it will be found that many of them are formed on the same principle, as shown in Fig. 27. The ovals of the letters

a b d p q o

c e

r n m h

w v y

til jf

FIG. 27.

a, b, d, g, p, and q are formed exactly alike and have a slant of 45° with the horizontal. These ovals should be made a little wider at the top than at the bottom. Care should be taken that the straight downward strokes are made parallel to the slanting guide lines. The letters *c* and *e* are commenced in the same way, but the upper loop in *e* should

be formed in such a manner that its axis will be at an angle

of 45° with the horizontal. The *r* is made by having the down stroke parallel to the slanting guide line and the up stroke slightly curved in the same way as in the letter *n* (see Fig. 27). The strokes in the letters *j* and *f* are the same, with the position of the hooked part reversed.

28. The capital letters shown in Fig. 28 are formed very nearly in the same manner as those shown in Art. 23,

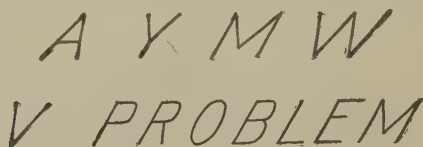


FIG. 28.

but differ slightly by omitting the short spurs that give to the letters a more finished appearance.

In the capital *M*, however, there is a decided variation. The *M* is made with four strokes, putting in the parallel sides first. The two other strokes should join midway between these sides and at a distance from the top of about $\frac{4}{5}$ of the height of the letter. These strokes, as will be seen, are straight and not curved.

29. The *numerals* should be $\frac{5}{8}$ " high and of the style shown in Fig. 25; fractions should be $\frac{1}{8}$ " high over all. In



FIG. 29.

Fig. 29 the numerals are illustrated to a larger scale, and a comparison with the style shown in Fig. 21 will disclose several variations.

The loops of the 2, 3, 5, 6, and 9 should be formed so that their axes will be at an angle of 45° with the horizontal. It will be noted that the 7 differs widely from the style shown in Fig. 21, the down stroke not curving but having a straight slant of 45° . The axis of the 0 and the loops of the 8 should slant at an angle of 60° .

Diligent practice for a short time and careful observation of the forms of letters and numerals as shown in Figs. 21-29 will soon enable the student to acquire skill and speed in this branch of drawing.

30. The alphabet shown in Fig. 30, called the **block letter**, is to be used for the large headings or titles of plates, as shown on the copy plates. This alphabet is *not* to be used on the first five geometrical drawing plates. The letters and figures are to be made $\frac{5}{16}$ " high and $\frac{1}{4}$ " wide, except *M*, which is $\frac{5}{16}$ " wide, and *W*, which is $\frac{3}{8}$ " wide. The thickness of all

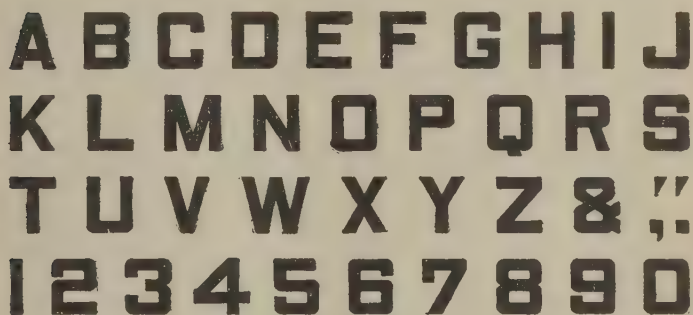


FIG. 30.

the lines forming the letters is $\frac{1}{16}$ ", measured horizontally. The distance between any two letters of a word is $\frac{1}{16}$ ", except where *A* follows *P* or *F*; where *V*, *W*, or *Y* follows *L*; where *J* follows *F*, *P*, *T*, *V*, *W*, or *Y*; where *T* and *A* are adjacent, or *A* and *V*, *W*, or *Y* are adjacent; in this case, the bottom extremity of *A* and the top extremity of *P*, *T*, *V*, *W* are in the same vertical line, etc.

31. Since these letters are composed of straight lines, they can be made with the **T** square and triangle. In lettering the title of the drawing plates, the student should draw six horizontal lines $\frac{1}{16}$ " apart in lead pencil, to represent the thickness of the letters at the top, center, and bottom; then, by use of the triangle, he should draw in the width of the letters and the spaces between them in lead pencil. Having the

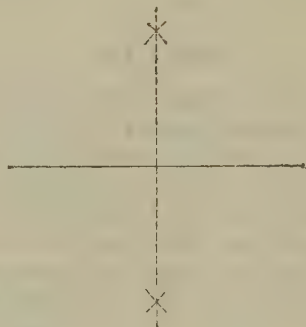
letters all laid out, he can very easily ink them in. Use the ruling pen for inking in the straight outlines of the letters, and the lettering pen for rounding the corners and filling in between the outlines. It is well to ink in all the perpendicular lines first, next the horizontal lines, and then the oblique lines.

PLATES.

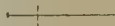
32. Preliminary Directions.—The size of each plate over all will be $14'' \times 18''$, having a border line $\frac{1}{2}''$ from each edge all around, thus making the size of the space on which the drawing is to be made $13'' \times 17''$. The sheet itself must be larger than this when first placed upon the board, so that the thumbtack holes may be cut out; the extra margin is also very convenient for testing the pen, in order to see whether the ink is flowing well and whether the lines are of the proper thickness.

The first five plates will consist of practical geometrical problems which constantly arise in practice when making drawings. The method of solving every one of these problems should be carefully memorized, so that they can be instantly applied when the occasion requires, without being obliged to refer to the text for help. Particular attention should be paid to the lettering. Whenever any dimensions are specified, they should be laid off as accurately as possible. All drawings should be made as neat as possible, and the penciling entirely finished before inking in any part of it. Great care should be taken in distributing the different views, parts, details, etc. on the drawing, so that when the drawing is completed, one view will not be so near to another as to mar the appearance of the drawing. The hands should be perfectly clean, and should not touch the paper except when necessary. No lines should be erased except when *absolutely* necessary; for, whenever a line has once been erased, the dirt flying around in the air and constantly falling on the drawing will stick to any spot where an

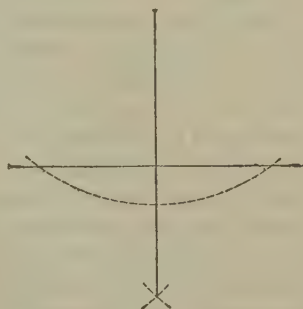
PROBLEM 1: To bisect a straight line.



PROBLEM 2: To draw

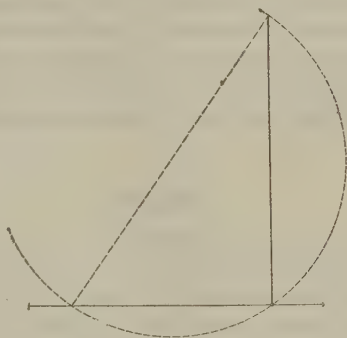


PROBLEM 3: To draw a perpendicular to a straight line from a point with
CASE 1.

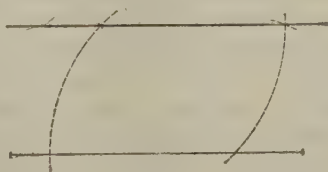


DATE

ular to a straight line from a given point in that line.
CASE II.



PROBLEM 4: Through a given point to draw
a straight line parallel to a given straight line.



NAME, CLASS LETTER AND NUMBER

$\frac{1}{2}$ "

erasure has been made, and it is then very difficult, if not impossible, to entirely remove it. For this reason, all construction lines that are to be removed, or that are liable to be changed, should be drawn lightly, that the finish of the paper may not be destroyed when erasing them. When it is found necessary to erase an ink blot or a line that has been inked in, only an *ink eraser* or *sand rubber* should be used. After the erasure has been made, the roughened part of the surface of the paper can be smoothed by rubbing with some hard, smooth substance, as a piece of ivory or the handle of a knife.

PLATE I.

33. Take a sheet of drawing paper 15" wide and 20" long (demy size), and fasten it to the board as previously described. On this draw the outlines of the size of the plate, 14" $\times$ 18", and draw the border line all around $\frac{1}{2}$ " from the edge of the outline, leaving the space inside for the drawing 13" $\times$ 17". When the word *drawing* is used hereafter, it refers only to the space inside the border lines and the objects drawn upon it. To understand clearly what follows, refer to Plate I. Divide the drawing into two equal parts by means of a faint horizontal line. This line is shown dotted in Plate I, above referred to. Divide each of these halves into three equal parts, as shown by the dotted lines; this divides the drawing into six rectangular spaces. *These division lines are not to be inked in, but must be erased when the plate is completed.* On the first five plates, space for the lettering must be taken into account. For each of the six equal spaces, the lettering will take up one or two lines. The height of all capital letters on these plates will be $\frac{3}{32}$ ", and of the small letters $\frac{2}{3}$ of this, or $\frac{1}{16}$ ". The distance between any two lines of lettering will also be $\frac{3}{32}$ ". The distance between the tops of the letters on the first line of lettering and the top line of the equal divisions of the drawing is to be $\frac{1}{2}$ "; and the space between the bottoms of the letters and the topmost point of the figure represented on the

drawing within one of these six divisions must also be not less than $\frac{1}{2}$ ". This makes a very neat arrangement, if the figure is so placed that the outermost points of the bounding lines are equally distant from the sides of one of the equal rectangular spaces. Consequently, if there is one line of lettering, no point of the figure drawn should come nearer than $\frac{1}{2}" + \frac{3}{32}" + \frac{1}{2}" = 1\frac{3}{32}"$ to the top line of the space within which it is represented; or, if there are two lines of lettering, nearer than $\frac{1}{2}" + \frac{3}{32}" + \frac{3}{32}" + \frac{1}{2}" = 1\frac{9}{32}"$. The letter heading for each figure on the first five plates will be printed in heavy-faced type at the beginning of the directions explaining each problem. The student must judge for himself by the length of the heading whether it will take up one line or two, and make due allowance for the space it takes up. This is a necessary precaution, because the lettering should never be done until the rest of the drawing is entirely finished and inked in.

PROBLEM 1.—To bisect a straight line.

See Fig. 31; also 1 of Plate I.

CONSTRUCTION.—Draw a straight line AB , $3\frac{1}{2}"$ long. With one extremity A as a center, and a radius greater than one-

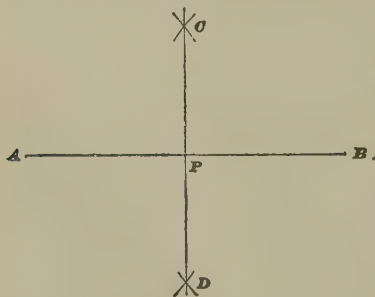


FIG. 31.

half of the length of the line, describe an arc of a circle on each side of the given line; with the other extremity B as a center, and the same radius, describe arcs intersecting the first two in the points C and D . Join C and D by the line CD , and the point P , where it intersects AB , will be the

required point; that is, $AP = PB$, and P is the middle point of AB . Since CD is perpendicular to AB , this construction also gives a *perpendicular to a straight line at its middle point*.

PROBLEM 2.—To draw a perpendicular to a straight line from a given point in that line.

NOTE.—As there are two cases of this problem, requiring two figures on the plate, the line of letters will be run clear across both figures, as shown in Plate I.

Case I.—When the point is at or near the center of the line. See Fig. 32; also 2, Case I, of Plate I.

CONSTRUCTION. — Draw AB $3\frac{1}{2}"$ long. Let P be the given point. With P as a center, and any radius, as PD , describe two short arcs cutting AB in the points C and D . With C and D as centers, and any convenient radius greater than PD , describe two arcs intersecting in E . Draw PE , and it will be perpendicular to AB at the point P .

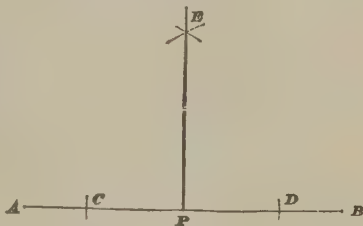


FIG. 32.

Case II.—When the point is near the end of the line. See Fig. 33; also 2, Case II, of Plate I.

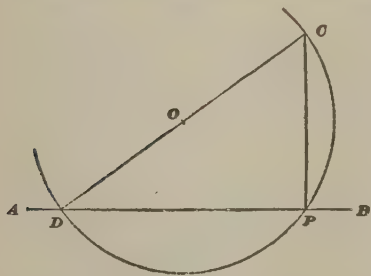


FIG. 33.

Draw AB $3\frac{1}{2}"$ long. Take the given point P about $\frac{3}{8}"$ from the end of the line. With any point O as a center, and a radius OP , describe an arc cutting AB in P and D . Draw DO , and prolong it until it intersects the arc in the point C . A line drawn through C and P will be perpendicular to AB at the point P .

PROBLEM 3.—To draw a perpendicular to a straight line from a point without it.

As in Problem 2, there are two cases.

Case I.—*When the point lies nearly over the center of the line.* See Fig. 34; also 3, Case I, of Plate I.

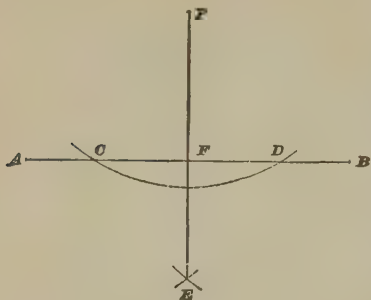


FIG. 34.

CONSTRUCTION.—Draw AB $3\frac{1}{2}''$ long. Let P be the given point. With P as a center, and any radius PD greater than the distance from P to AB , describe an arc cutting AB in C and D . With C and D as centers, and any convenient radius, describe short arcs intersecting

in E . A line drawn through P and E will be perpendicular to AB at F .

Case II.—*When the point lies nearly over one end of the line.* See Fig. 35; also 3, Case II, of Plate I.

Draw AB $3\frac{1}{2}''$ long, and let P be the given point. With any point C on the line AB as a center, and the distance CP as a radius, describe an arc $PE D$ cutting AB in E . With E as a center, and the distance EP as a radius, describe an arc cutting the arc $PE D$ in D .

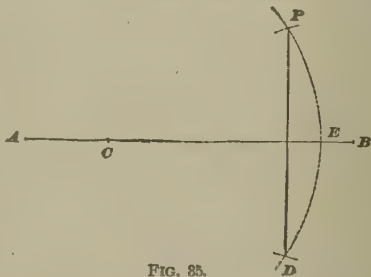


FIG. 35.

The line joining the points P and D will be perpendicular to AB .

PROBLEM 4.—Through a given point, to draw a straight line parallel to a given straight line.

See Fig. 36; also 4 of Plate I.

CONSTRUCTION.—Let P be the given point, and AB the given straight line $3\frac{1}{2}''$ long. With P as a center, and any

convenient radius, describe an arc CD intersecting AB in D . With D as a center, and the same radius, describe the arc PE . With D as a center, and a radius equal to the

chord of the arc PE , describe an arc intersecting CD in C . A straight line drawn through P and C will be parallel to AB .

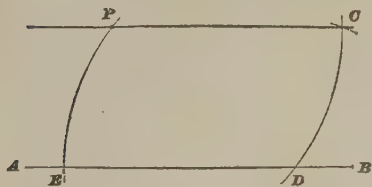


FIG. 36.

34. These four problems form Plate I. They

should be carefully and accurately drawn in with lead-pencil lines and then inked in. It will be noticed that on Plate I, and Figs. 31 to 36, the given lines are *light*, the required lines *heavy*, and the construction lines, which, in a practical working drawing, would be left out, are *light dotted*. This system must also be followed in the four plates which are to follow. A single glance enables one to see at once the reason for drawing the figure, and the eye is directed immediately to the required line.

In the first five plates, accuracy and neatness are the main things to be looked out for. The student should be certain that the lines are of *precisely* the length that is specified in the description. When drawing a line through two points, be sure that the line goes through the points; if it does not pass exactly through the points, erase it and draw it over again. If a line is supposed to end at some particular point, make it end there—do not let it extend beyond or fall short. Thus, in Fig. 36, if the line PC does not pass through the points P and C , it is not parallel to AB . By paying careful attention to these points, the student saves himself a great deal of trouble in the future. *Do not hurry your work.*

First ink in all of the light lines and light dotted lines (which have the same thickness); then ink in the heavy required lines after the pen has been readjusted. Now do the lettering (first read carefully the paragraphs under the head "Lettering"), and finally draw the heavy border lines, which

should be thicker than any other line on the drawing. The word "Plate" and its number should be printed at the top of the sheet, outside the border lines, and midway of its length, as shown. The student's name, followed by the words "Class" and "No.," and after this his course letter and *class number* should be printed in the lower right-hand corner below the border line, as shown. Thus, John Smith, Class No. C 4529. The date on which the drawing was completed should be placed in the lower left-hand corner, below the border line. *All of this lettering is to be in capitals $\frac{3}{8}$ " high.* Erase the division lines, and clean the drawing by rubbing very gently with the eraser. Care must be exercised when doing this, or the inked lines will also be erased. It is best to use a so-called "Sponge Rubber" for this purpose, as it will not injure the inked lines. *If any part of a line has been erased or weakened, it must be redrawn.* Then write with the lead pencil your name and address in full on the back of your drawing, after which put your drawing in the empty tube which was sent you, and send it to the Schools.

HINTS FOR PLATE I.

35. *Do not forget to make a distinction between the width of the given and required lines, nor forget to make the construction lines dotted.*

When drawing dotted lines, take pains to have the dots and spaces uniform in length. Make the dots about $\frac{1}{16}$ " long and the spaces only about one-third the length of the dots.

Try to get the work accurate. The constructions must be accurate, and all lines or figures should be drawn of the length or size previously stated. To this end, work carefully and keep the pencil leads very sharp, so that the lines will be fine.

The lettering on the first few plates, as well as on the succeeding plates, is fully as important as the drawing, and should be done in the neatest possible manner. Drawings sent

in for correction with the lettering omitted will be returned for completion.

The reference letters like A, B, C, etc., as shown in Fig. 31, are not to be put on the plates.

Do not neglect to trim the plates to the required size. Do not punch large holes in the paper with the dividers or compasses. Remember that the division lines are to be erased—not inked in.

PLATE II.

36. Draw the division lines in the same manner as described for Plate I. The following five problems, Nos. 5 to 9, inclusive, are to be drawn in regular order, as was done in Plate I, with problems from 1 to 4. The letter headings are given in heavy-faced type after the problem number.

PROBLEM 5.—To bisect a given angle.*

CASE I.—*When the sides intersect within the limits of the drawing.* See Fig. 37.

CONSTRUCTION.—Let AOB be the angle to be bisected. Draw the sides OA and OB $3\frac{1}{2}$ " long. With the vertex O as a center, and any convenient radius, describe an arc DE intersecting OA at D and OB at E . With D and E

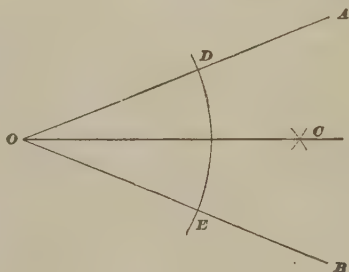


FIG. 37.

as centers, and a radius greater than the chord of half the arc DE , describe two arcs intersecting at C . The line drawn through C and O will bisect the angle; that is, $AOC = COB$.

*Since the letter heading in this problem is very short, it will be better to place it over each of the two cases separately, instead of running it over the division line, as was done with the long headings of the two cases in Plate I. Put Case I and Case II under the heading, as in the previous plate.

Case II.—*When the sides do not intersect within the limits of the drawing.* See Fig. 38.

Draw two lines, AB and CD , each $3\frac{1}{2}"$ long, and inclined towards each other as shown. With any point E on CD as a center, and any convenient radius, describe arc $FIGH$; with G as a center and same radius, describe arc $HLEF$, intersecting $FIGH$ in H and F . With L as a center, and same radius, describe arc KGJ ; with I as a center, and same radius, describe arc JEK , intersecting KGJ in K and J . Draw HF and JK ; they intersect at O , a point on the bisecting line. With O as a center, and the

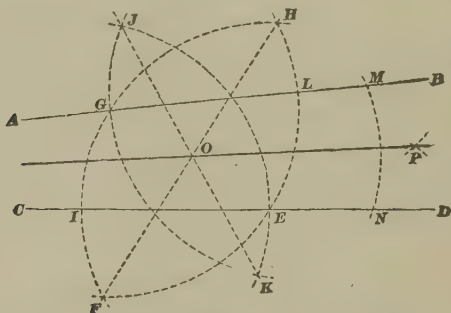


FIG. 38.

same or any convenient radius, describe an arc intersecting AB and CD in M and N . With M and N as centers, and any radius greater than one-half MN , describe arcs intersecting at P . A line drawn through O and P is the required bisecting line.

PROBLEM 6.—**To divide a given straight line into any required number of equal parts.**

See Fig. 39 (*a*).

CONSTRUCTION.— AB is the given line $3\frac{7}{16}"$ long. It is required to divide it into eight equal parts. Through one extremity A of the line, draw an indefinite straight line AC , making any angle with AB . Set the dividers to any

convenient distance, and space off eight equal divisions on AC , as AK, KI, IH , etc. Join C and B by the straight line CB , and through the points D, E, F, G , etc. draw lines DL, EM , etc. parallel to CB , by using the two triangles; these parallels intersect AB in the points L, M, N , etc., which are equally distant apart. The spaces LM, MN, NO , etc. are each equal to $\frac{1}{8} AB$. Proceed in a similar way for any number of equal parts into which AB is to be divided.

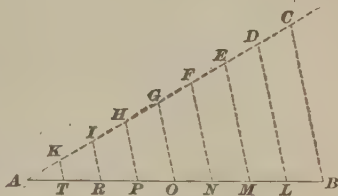


FIG. 39 (a).

An important modification of the method just described is shown in Fig. 39 (b). Draw AB as before, and erect the perpendicular BC . Now divide $3\frac{7}{16}$ ", the length of AB , by 8, the number denoting the number of equal parts into which AB is to be divided, obtaining $3\frac{7}{16}" \div 8 = \frac{3}{8}" + 1\frac{7}{28}"$, dividing the whole number and the fraction separately. Now considering $\frac{3}{8}" + 1\frac{7}{28}"$ to be approximately equal to $\frac{1}{2}"$,

multiply $\frac{1}{2}"$ by 8, the number of parts into which AB is to be divided; the result is $\frac{1}{2}" \times 8 = 4"$, which is the length of AC . With A as a center and a radius equal to $4"$ describe an arc cutting BC in C , and draw AC . Then with a scale lay off $AK = KI = \text{etc.} = \frac{1}{2}"$, and project K, I, H , etc. upon AB , in T, R, P , etc., the required points. The advantage of this method over the other is that the T square and triangle can be used throughout, thus making it very much easier to draw the parallels DL, EM , etc.

The student, when drawing this plate, is at liberty to use either of the two methods given in this problem.

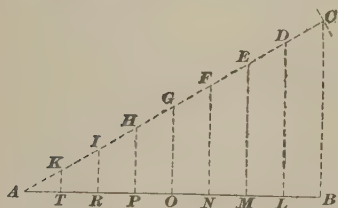


FIG. 39 (b).

C and D . With C and D as centers, and the same radius, describe arcs cutting the semicircle in H and K . Draw BH and BK , and prolong them to meet EF in E and F . BEF is the required equilateral triangle.

This problem finishes Plate II. The directions for inking in, lettering, etc. are the same as for Plate I.

PLATE III.

37. This plate is to be divided up like Plates I and II, and the six following problems are to be drawn in a similar manner:

PROBLEM 10.—Two sides and the included angle of a triangle being given, to construct the triangle.

CONSTRUCTION.—In Fig. 43, make the given sides MN $2\frac{1}{2}$ " long and PQ $1\frac{7}{8}$ " long. Let O be the given angle. Draw AB , and make it equal in length to PQ . Make the angle CBA equal to the given angle O , and make CB equal in length to the line MN . Draw CA , and CAB is the required triangle.

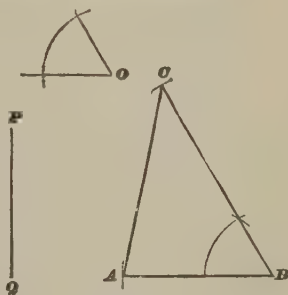


FIG. 43.

PROBLEM 11.—To draw a parallelogram when the sides and one of the angles are given.

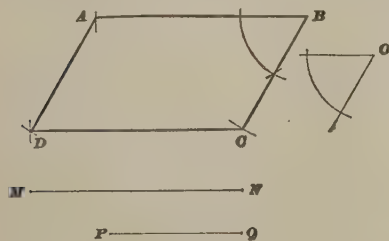


FIG. 44.

CONSTRUCTION.— In Fig. 44, make the given sides MN $2\frac{1}{2}$ " long and PQ $1\frac{7}{8}$ " long. Let O be the given angle. Draw AB equal to MN , and draw BC , making an angle with AB equal to the given angle O .

Make BC equal to PQ . With C as a center, and a radius equal to MN , describe an arc at D . With A as a center, and a radius equal to PQ , describe an arc intersecting the other arc in D . Draw AD and CD , and $ABCD$ is the required parallelogram.

PROBLEM 12.—An arc and its radius being given, to find the center.

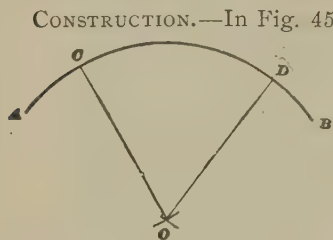


FIG. 45.

CONSTRUCTION.—In Fig. 45, $ACDB$ is the arc, and MN , $1\frac{3}{4}$ " long, is the radius. With MN as a radius, and any point C in the given arc as a center, describe an arc at O . With any other point D in the given arc as a center, and the same radius, describe an arc intersecting the first in O . O is the required center.

PROBLEM 13.—To pass a circumference through any three points not in the same straight line.

CONSTRUCTION.—In Fig. 46, A , B , and C are the given points. With A and B as centers, and any convenient radius, describe arcs intersecting each other in K and I . With B and C as centers, and any convenient radius, describe arcs intersecting each other in D and E . Through I and K and through D and E , draw lines intersecting at O . With O as a center, and OA as a radius, describe a circle; it will pass through A , B , and C .

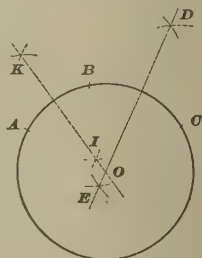


FIG. 46.

PROBLEM 14.—To inscribe a square in a given circle.

CONSTRUCTION.—In Fig. 47, the circle $ABCD$ is $3\frac{1}{2}$ " in diameter. Draw two diameters, AC and DB , at right angles to each other. Draw the lines AB , BC , CD , and DA joining the points of intersection of these diameters

with the circumference of the circle, and they will be the sides of the square.

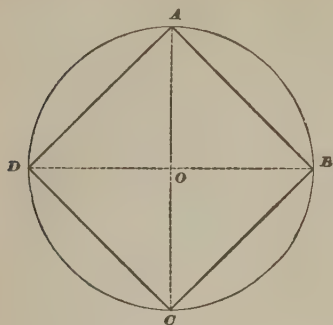


FIG. 47.

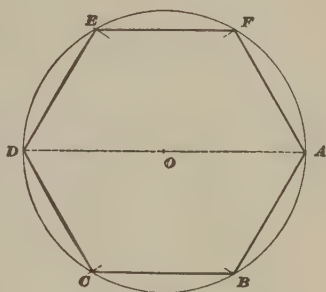


FIG. 48.

PROBLEM 15.—To inscribe a regular hexagon in a given circle.

CONSTRUCTION.—In Fig. 48, from O as a center, with the dividers set to $1\frac{3}{4}''$, describe the circle $A B C D E F$. Draw the diameter $D O A$, and from the points D and A , with the dividers set equal to the radius of the circle, describe arcs intersecting the circle at E, C, F , and B . Join these points by straight lines, and they will form the sides of the hexagon. This problem completes Plate III.

PLATE IV.

38. The first four problems on this plate are more difficult than any on the preceding plates and will require very careful construction. All the sides of each polygon must be of exactly the same length, so that they will space around evenly with the dividers. The figures should not be inked in until the pencil construction is done accurately. The preliminary directions for this plate are the same as for the preceding ones.

PROBLEM 16.—To inscribe a regular pentagon in a given circle.

CONSTRUCTION.—In Fig. 49, from O as a center, with the dividers set to $1\frac{3}{4}''$, describe the circle $A B C D$. Draw the two diameters $A C$ and $D B$ at right angles to each other. Bisect one of the radii, as $O B$, at I . With I as a center, and $I A$ as a radius, describe the arc $A J$ cutting $D O$ at J . With A as a center, and $A J$ as a radius, describe an arc $J H$ cutting the circumference at H . The chord $A H$ is one side of the pentagon.

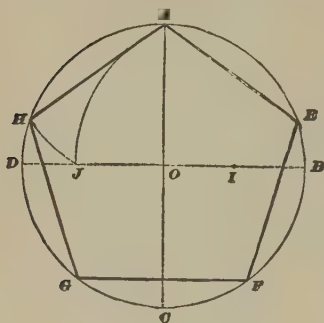


FIG. 49.

PROBLEM 17.—To inscribe a regular octagon in a given circle.

CONSTRUCTION.—In Fig. 50, from O as a center, with the dividers set to $1\frac{3}{4}''$, describe the circle $A B C D E F G H$. Draw the two diameters $A E$ and $G C$ at right angles to each other. Bisect one of the four equal arcs, as $A G$ at H , and draw the diameter $H O D$. Bisect another of the equal arcs, as $A C$ at B , and draw the diameter $B O F$. Straight lines drawn from A to B , from B to C , etc., will form the required octagon.

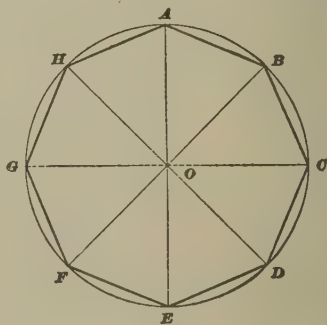


FIG. 50.

PROBLEM 18.—To inscribe a regular polygon of any number of sides in a given circle.

CONSTRUCTION.—In Fig. 51, from O as a center, with the

dividers set to $1\frac{3}{4}$ ", describe the circle $A7CD$. Draw the two diameters $D7$ and AC at right angles to each other. Divide the diameter $D7$ into as many equal parts as the polygon has sides (in this case seven). Prolong the diameter AC and make $3'A$ equal to three-fourths of the radius OA . Through $3'$ and 2, the second division from D on the diameter $D7$, draw the line $3'I$, cutting the circumference at I . Draw the chord DI , and it is one side of the required polygon. The others may be spaced off around the circumference.

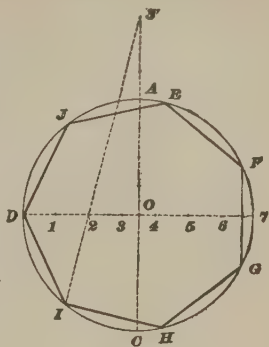


FIG. 51.

PROBLEM 19.—The side of a regular polygon being given, to construct the polygon.

CONSTRUCTION.—In Fig. 52, let AC be the given side. If the polygon is to have eight sides, the line AC should be, for this plate, $1\frac{1}{4}$ " long. Produce AC to B . From C as center, with a radius equal to CA , describe the semicircle $A1234567B$, and divide it into as many equal parts as there are sides in the required polygon (in this case eight). From the point C , and through the second division from B , as 6, draw the straight line $C6$. Bisect the

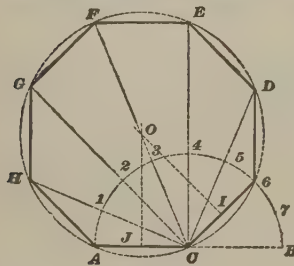


FIG. 52.

lines AC and $C6$ by perpendiculars intersecting in O . From O as a center, and with OC as a radius, describe the circle $CAHGFED6$. From C , and through the points 1, 2, 3, 4, 5 in the semicircle, draw lines CH , CG , CF , etc. meeting the circumference. Joining the points 6 and D , D and E , E and F , etc. by straight lines, will complete the required polygon.

PROBLEM 20.—To find an arc of a circle having a known radius, which shall be equal in length to a given straight line.

NOTE.—There is no exact method, but the following approximate method is close enough for all practical purposes, when the required arc does not exceed $\frac{1}{8}$ of the circumference.

CONSTRUCTION.—In Fig. 53, let AC be the given line $3\frac{1}{2}$ " long. At A , erect the perpendicular AO , and make it

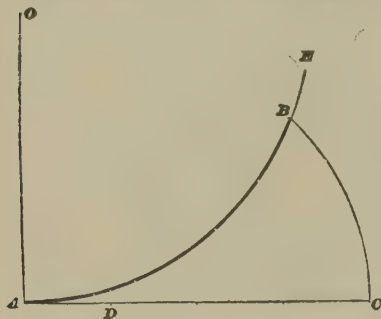


FIG. 53.

equal in length to the given radius, say 4" long. With OA as a radius, and O as a center, describe the arc ABE . Divide AC into four equal parts, AD being the first of these parts, counting from A . With D as a center, and a radius DC , describe the arc CB intersecting

ABE in B . The length of the arc AB very nearly equals the length of the straight line AC .

PROBLEM 21.—An arc of a circle being given, to find a straight line of the same length.

This is also an approximate method, but close enough for practical purposes, when the arc does not exceed $\frac{1}{8}$ of the circumference.

CONSTRUCTION.—In Fig. 54, let AB be the given arc; find the center O of the arc, and draw the radius OA . For this problem, choose the arc so that the radius will not exceed $1\frac{3}{4}$ ". At A , draw AC perpendicular to the radius (and, of course, tangent to the arc).

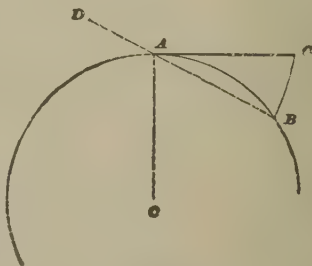


FIG. 54.

Draw the chord AB , and prolong it to D , so that $AD = \frac{1}{2}$ the chord AB . With D as a center, and a radius DB , describe the arc BC cutting AC in C . AC will be very nearly equal to the arc AB .

PLATE V.

39. On this plate there are five problems instead of six. It should be divided into six equal parts or divisions, as the previous ones. The two right-hand end divisions are used to draw in the last figure of Plate V, which is too large to put in one division.

PROBLEM 22.—To draw an egg-shaped oval.

CONSTRUCTION.—In Fig. 55, on the diameter AB , which is $2\frac{3}{4}"$ long, describe a circle $ACBG$. Through the center O , draw OC perpendicular to AB , cutting the circumference $ACBG$ in C . Draw the straight lines BCF and ACE . With B and A as centers, and the diameter AB as a radius, describe arcs terminating in D and H , the points of intersection with BF and AE . With C as a center, and CD as a radius, describe the arc DH . The curve $ADHBG$ is the required oval.

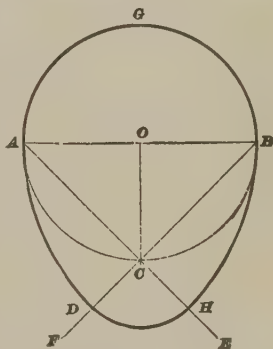


FIG. 55.

PROBLEM 23.—To draw an ellipse, the diameters being given. The exact method.

CONSTRUCTION.—In Fig. 56, let BD , the long diameter, or major axis, which is $3\frac{1}{2}"$ long, and AC , the short diameter, or minor axis, which is $2\frac{1}{4}"$ long, intersect at right angles to each other in the center O , so that $DO = OB$ and $AO = OC$. With O as a center, and OC as a radius, describe a circle; with the same center, and OD as a radius, describe another circle. Divide both circles into the same

number of equal parts, as 1-2, 2-3, etc. This is best done by first dividing the larger circle into the required number of parts, beginning at the center line AC , and then drawing radial lines through the points of division on this circle,

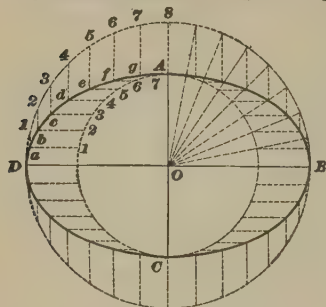


FIG. 56.

to the center O of the circles, as shown in the upper right-hand quarter of the figure. The radial lines will divide the smaller circle into the same number of parts that the larger one has been divided into. Through the points of division on the smaller circle, draw horizontal lines, and, through the points of division on the

larger circle, draw vertical lines; the points of intersection of these lines are points on the ellipse. Thus, the horizontal line Sc and the vertical line Sc intersecting at c give the point c of the ellipse. Trace a curve through the points thus found by placing an irregular curve on the drawing in such a manner that one of its bounding lines will pass through three or more points, judging with the eye whether the curve so traced bulges out too much or is too flat. Then adjust the curve again, so that its bounding line will pass through several more points, and so on, until the curve is completed. Care should be taken to make all changes in curvature as gradual as possible, and all curves drawn in this manner should be drawn in pencil before being inked in. It requires considerable practice to be able to draw a good curved line in this manner by means of an irregular curve, and the general appearance of a curve thus drawn depends a great deal upon the student's taste and the accuracy of his eye.

PROBLEM 24.—To draw an ellipse by circular arcs.

This is not a true ellipse, but is very convenient for many purposes.

CONSTRUCTION.—In Fig. 57, use the same dimensions as before. On the major axis AB , set off $Aa = CD$, the minor axis, and divide aB into three equal parts.

With O as a center, and a radius equal to the length of two of these parts, describe arcs cutting AB in d and d' . Upon dd' as a side, construct two equilateral triangles dbd' and $d'b'd'$. With b as a center, and a radius equal to bD , describe the arc gDf

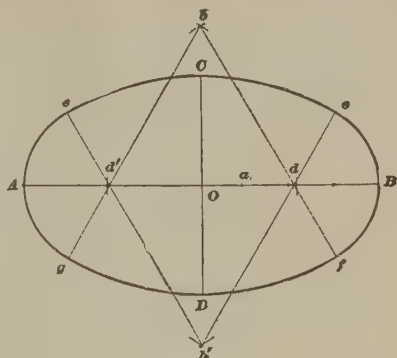


FIG. 57.

intersecting $bd'f$ and $b'd'g$ in f and g . With the same radius, and b' as a center, describe the arc cCe intersecting $b'd'c$ and $b'd'e$ in c and e . With A and B as centers, and a radius equal to the chord of the arcs Ac or Be , describe arcs cutting AB very near to d' and d . From the points of intersection of these arcs with AB as centers, and the same radius, describe the arcs cAg and eBf .

PROBLEM 25.—To draw a parabola, the axis and longest double ordinate being given.

EXPLANATION.—The curve shown in Fig. 58 is called a **parabola**. This curve and the ellipse are the bounding line of certain sections of a cone. The line OA , which bisects the area included between the curve and the line BC , is called the **axis**. Any line, BA or AC , drawn perpendicular to OA , and whose length is included between OA and the curve, is called an **ordinate**. Any line, as BC , both of whose extremities rest on the curve, and is perpendicular to the axis, is called a **double ordinate**. Point O is called the **vertex**.

CONSTRUCTION.—Make the axis OA equal to $3\frac{1}{2}''$, and the longest double ordinate BC equal to $3''$. BA , of course, equals AC . Draw DE through the other extremity of the

axis and perpendicular to it; also draw BD and CE parallel to OA and intersecting DE in D and E . Divide DB and AB into the same number of equal parts, as shown (in this case six); through the vertex O , draw $O1$, $O2$, etc. to the points of division on DB , and through the corre-

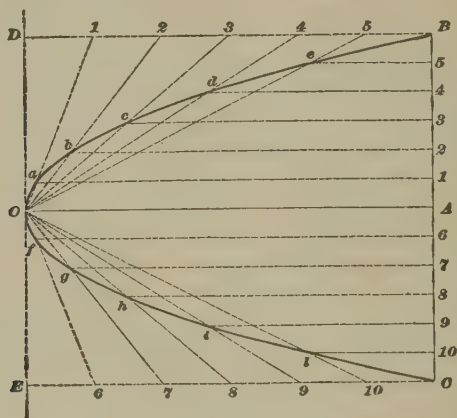


FIG. 58.

sponding points $1, 2$, etc., on AB , draw lines parallel to the axis. The points of intersection of these lines, a, b, c , etc., are points on the curve, through which it may be traced. In a similar manner, draw the lower half $O f g h i l C$ of the curve.

PROBLEM 26.—To draw a helix, the pitch and the diameter being given.

EXPLANATION.—The helix is a curve formed by a point moving around a cylinder and at the same time advancing along its length a certain distance; this forms the winding curved line shown in Fig. 59. The center line AO , drawn through the cylinder, is called the **axis** of the helix, and any line perpendicular to the axis and terminated by the helix is of the same length, being equal to the radius of the cylinder. The distance $B12$ that the point advances lengthwise during one revolution is called the **pitch**.

CONSTRUCTION.—As mentioned before, this figure occupies two spaces of the plate. The diameter of the cylinder is $3\frac{1}{2}$ ", the pitch is 2", and a turn and a half of the helix is to be shown. The rectangle $FBE D$ is a side view of the cylinder, and the circle $1' 2' 3' 4'$, etc. is a bottom view. It will be noticed that one-half of a turn of the helix is shown

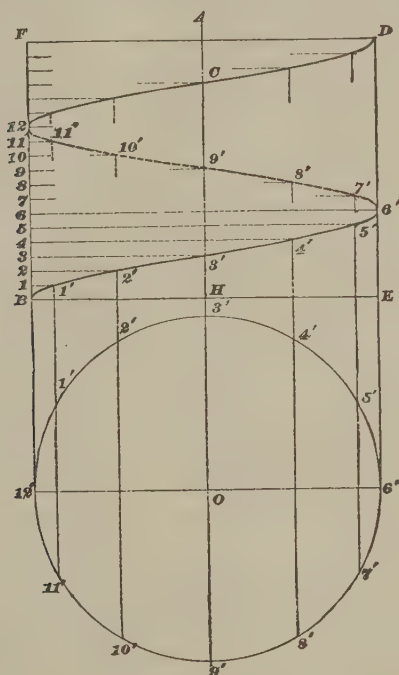


FIG. 59.

dotted; this is because that part of it is on the other side of the cylinder, and cannot be seen. Lines that are hidden are drawn dotted. Draw the axis OA in the center of the space. Draw FD , $3\frac{1}{2}$ " long and 4" from the top border line; on it construct a rectangle whose height $FB = 3$ ". Take the center O of the circle $2\frac{3}{4}$ " below the point H on the axis AO , and describe a circle having a diameter of $3\frac{1}{2}$ " equal to the

diameter of the cylinder. Lay off the pitch from B to 12 equal to $2''$, and divide it into a convenient number of equal parts (in this case 12), and divide the circle into the same number of equal parts, beginning at one extremity of the diameter $12' O 6'$, drawn parallel to BE . At the point $1'$ on the circle divisions, erect $1'-1''$ perpendicular to BE ; through the point 1 of the pitch divisions, draw $1-1''$ parallel to BE , intersecting the perpendicular in $1''$, which is a point on the helix. Through the point $2'$, erect a perpendicular $2'-2''$, intersecting $2-2''$ in $2''$, which is another point on the helix. So proceed until the point 6 is reached; from here on, until the point 12 of the helix is reached, the curve will be dotted. It will be noticed that the points of division $7', 8', 9', 10'$, and $11'$ on the circle are directly opposite the points $5', 4', 3', 2'$, and $1'$; hence, it was not necessary to draw the lower half of the circle, since the point $5'$ could have been the starting point, and the operation could have been conducted backwards to find the points on the dotted upper half of the helix. The other full-curved line of the helix can be drawn in exactly the same manner as the first half.

This ends the subject of practical geometry. Mechanical drawing, or the representation of objects on plane surfaces, will now be commenced.

THE REPRESENTATION OF OBJECTS.

40. There are five kinds of lines used in mechanical drawing, thus:

The light full line. _____

The dotted line. _____

*The broken and
dotted line.* _____

The broken line. _____

The heavy full line. _____

The light full line is used the most; it is used for drawing the outlines of figures, and all other parts that can be seen by the eye.

The dotted line, consisting of a series of very short dashes, is used in showing the position and shape of that part of the object represented by the drawing, which is concealed from the eye in the view shown; for example, a hollow prism closed on all sides. The hollow part cannot be seen; hence, its size, shape, and position are represented by dotted lines.

The broken and dotted line, consisting of a long dash, and two dots or very short dashes repeated regularly, is used to indicate the center lines of the figure or parts of the figure, and also to indicate where a section has been taken when a sectional view is shown. This line is sometimes used for construction lines in geometrical figures.

The broken line, consisting of a series of long dashes, is used in putting in the dimensions, and serves to prevent the dimension lines from being mistaken for lines of the drawing.

The heavy full lines are made not less than twice as thick as the light full lines, and are used for shade lines.

Further explanations in regard to these lines will be given when the necessity for using them arises.

41. The illustrations in this and the following paragraph should be carefully studied, but the student is not required to send in drawings from same. In Fig. 60 is shown a perspective view of a frustum of a pyramid having a rectangular base and a hole passing through the center of the frustum. This figure represents the frustum as it actually appears when the eye of the observer is in a certain position. The

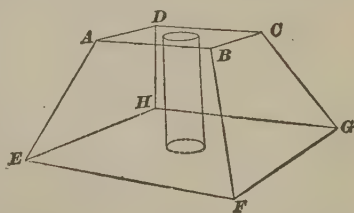


FIG. 60.

The angles at A , B , C , and D are right angles, the hole is round, and the sides AB and DC are of equal lengths; so also

are AD and BC ; but, if they were measured on the drawing, it would be found that their lengths are all different. The same difficulty would be met with in trying to measure the angles and edges of the sides $ABFE$, $BFGC$, etc. The real lengths of any line could be found only by a person perfectly familiar with perspective drawing, and then only with great difficulty. Consequently, this method of representing objects is of no use to a patternmaker, carpenter, machinist, or engineer, except to show what the object looks like. In order to represent the object in such a manner that any line or angle can be measured directly, what is termed **projection drawing**, or *orthographic projection*, is universally employed. In the perspective drawing shown in Fig. 60, three sides of the frustum are shown, and the other three are hidden; in a projection drawing, but one

side is usually shown, the other five being hidden.

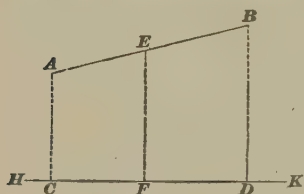


FIG. 61.

A line or surface is *projected* upon a plane, by drawing perpendicular lines from points on the line or surface to the plane, and joining them.

Thus, if perpendiculars be drawn from the extremities of a line, as AB , to another line HK , as shown in Fig. 61, that portion of HK included between the feet of these perpendiculars is called the **projection** of AB upon HK . Thus, CD is the projection of AB upon HK , the point C is the projection of the point A upon HK , and the point D is the projection of the point B upon HK .

The projection of any point of AB , as E , can be found by drawing a perpendicular from E to HK , and the point where this perpendicular intersects HK is its projection. In this case, the point F is the projection of the point E upon HK .

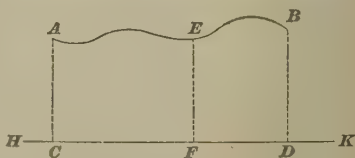


FIG. 62.

It makes no difference whether the line is straight or curved—the method of finding the projection is exactly the same. See Fig. 62.

In a similar way, a surface is projected upon a flat surface.

Thus, it is desired to project the irregular surface $abcd$, Fig. 63, upon the flat surface $ABDC$. Draw the lines aa' , bb' perpendicular to the flat surface; join the points a' and b' , where these perpendiculars intersect the flat surface $ABDC$, by a straight line $a'b'$, and $a'b'$ is the projection of the line ab upon $ABDC$.

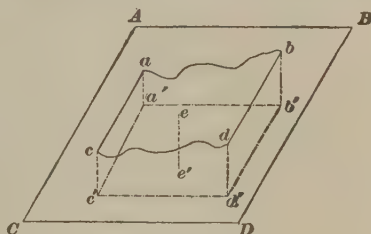


FIG. 63.

In the same way, $a'c'$ is found to be the projection of ac ; $c'd'$, the projection of cd ; and $d'b'$, the projection of db . Hence, the projection of the irregular surface $abcd$ upon the flat surface $ABDC$ is the quadrilateral $a'b'd'c'$.

The projection of any point, as e , is found as before, by drawing a perpendicular from the point e to the surface; thus, e' is the projection of the point e upon the plane $ABDC$.

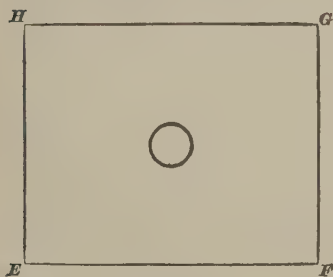


FIG. 64.

Suppose that the frustum, Fig. 60, were placed on a plane surface (a surface perfectly flat like a surface plate), and the outline of the bottom were traced by passing a pencil along its edges, including the round hole, the result would look like Fig. 64, in which the rectangle $EFGH$ represents the bottom of the frustum and the circle represents the hole.

The angles and lengths of the sides are exactly the same as they are on the frustum itself; a similar drawing could be made to represent the top, but it is unnecessary, for the reason that the top can be projected on Fig. 64, and both objects

accomplished in one drawing. Fig. 65 illustrates the meaning of the last statement. Here $A'B'$ is the projection of the edge AB , Fig. 60; $B'C'$, of BC , etc. $A'E'$ is the projection of the edge AE ; $B'F'$, of BF , etc. This drawing

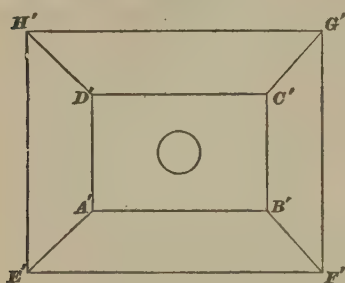


FIG. 65.

shows the figure as it would look if the eye were directly over it. A drawing which represents the object as if it were resting on a horizontal plane, and the observer looking at it from above, is called a **top view**, or **plan**. The line of vision is thus perpendicular to the faces $ABCD$ and $EFGH$

of the frustum. The lines AB , BC , etc., EF , FG , etc., and the diameter of the hole, can be measured directly. The drawing is not yet complete, since it does not show whether the ends and sides are rounding, hollowed out, or flat. For this purpose, two more views are necessary—a *vertical projection*, or *front view*, commonly called a **front elevation**, and a *side projection*, or **side view**. A front view (elevation) is drawn by imagining the eye to be so situated that the observer looks directly at the front of the object; in other words, the line of vision is parallel to the faces of the frustum. The side looked at is then drawn as if it were projected on a vertical plane at right angles to the horizontal plane, the vertical plane being also parallel to the edges EF and HG of the frustum shown in Fig. 60. The drawing would then look like Fig. 66. Here the trapezoid $ABFE$ represents the side $ABFE$ of the frustum; the altitude of the trapezoid being the same as the altitude of the frustum, it can be measured directly. The hole cannot be seen when the

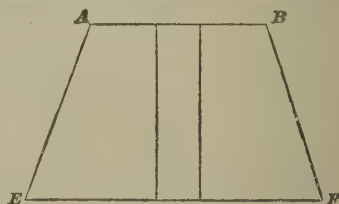


FIG. 66.

look like Fig. 66. Here the trapezoid $ABFE$ represents the side $ABFE$ of the frustum; the altitude of the trapezoid being the same as the altitude of the frustum, it can be measured directly. The hole cannot be seen when the

observer looks at the frustum in this position; hence, it is indicated by dotted lines. The projections of the lines AB and DC (also, of EF and HG , of AE and DH , and of BF and CG coincide.

To draw the side view (sometimes called a **side elevation**), imagine the frustum to be revolved around on its axis 90° to the left, and then draw it in precisely the same manner as the front elevation, by projecting the different lines upon a plane at right angles to the horizontal plane, and perpendicular to the edges EF and HG , that is, parallel to BC and FG . The side elevation would then be drawn as shown in Fig. 67. In this view the lines AD and BC (also, EH and FG , DH and CG , and AE and BF) coincide.

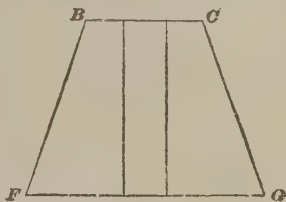


FIG. 67.

42. In order to show clearly the different views, and to guard against one view being mistaken for another, they are always arranged on the drawing in a certain fixed and invariable manner. Fig. 68 shows this method of arrangement. The plan is drawn first, then the two elevations. It is usually immaterial which of these views is drawn first, but the general arrangement is as shown. Any departure from this method of arrangement should be distinctly specified on the drawing in writing, unless the purpose of the draftsman is so clearly evident that no explanation is needed. The broken and dotted lines are the **center lines**; they serve to show the connection existing between the different views of the object, and to indicate axes of cylindrical surfaces of any kind. It will be noticed that, in the plan view, the two center lines cross each other at right angles, and that their point of intersection O is the center of the circle which represents the hole. Whenever a circle is drawn, two center lines should also be drawn through its center at right angles to each other; this enables any one looking at a drawing to

instantly locate the center of any circle. This remark also applies to ellipses, semicircles, etc.

To draw the frustum as shown in the last figure, either the front elevation or the plan is drawn first—whichever happens to be more convenient. Suppose the front elevation to be drawn first. Draw the vertical center line mn ; measure the altitude of the frustum, and lay it off on this line, locating

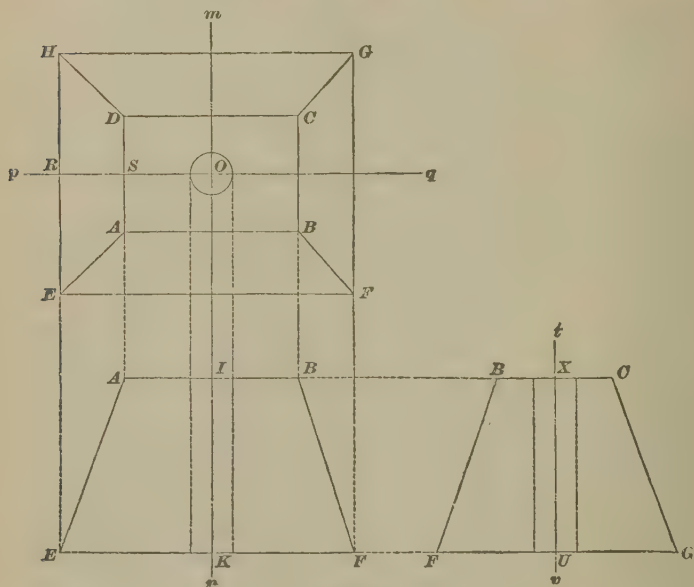


FIG. 68.

the points I and K ; through these points, draw the lines AB and EF perpendicular to mn ; make $AI = IB = \frac{1}{2} AB$, measured on the frustum; also $EK = KF = \frac{1}{2} EF$, measured on the frustum, and draw AE and BF . Lay off the radius of the circular hole on both sides of the center line mn , and draw the dotted lines parallel to mn through the extremities of these radii to represent the hole. The front elevation is now complete. To draw the plan, decide where the center is to be located on mn , and draw the horizontal

center line pq . With the point of intersection O of the two center lines as a center, and with a radius equal to the radius of the hole, describe a circle. Through the points A , B , E , and F , draw indefinite straight lines parallel to mn . On both sides of the center line pq , lay off on these lines DS and SA , equal to $\frac{1}{2}DA$, and HR and RE , equal to $\frac{1}{2}HE$, both DA and HE being measured on the frustum. Through the points H , E , D , and A , draw the lines HG , EF , DC , and AB , and join the points H and D , E and A , F and B , and G and C by straight lines, as shown. The figure thus drawn will be the plan.

To draw the side elevation, prolong the lines AB and EF , and draw the center line tv . Lay off, on each side of tv , FU and UG equal to $\frac{1}{2}FG$, measured on the frustum, and BX and XC equal to $\frac{1}{2}BC$, measured on the frustum. Join B and F , and C and G , by the straight lines BF and CG , and draw the hole dotted as in the front elevation. The drawing is now complete.

The student should have by this time a good idea of how simple objects may be represented by the different views of a drawing, and can now begin on the next plate.

DRAWING PLATE, TITLE: PROJECTIONS—I.

43. In making actual drawings of objects when the size of the plate is limited, it is usually impossible to divide it up into a certain number of parts, as in the case of the preceding plates, for the various figures differ widely in their sizes. These drawings should be so made that no part will come nearer than $\frac{3}{4}$ " to the border line, and the figures should be so arranged as to present a pleasing appearance to the eye and not be scattered aimlessly all over the drawing.

Fig. 1 represents a rectangular prism 2" long, $1\frac{1}{2}$ " wide, and $\frac{3}{4}$ " thick. The prism is represented as if it were standing on one of its small ends, with the broad side towards the observer. The elevation $ABDC$ is drawn first; in this case, it will be a rectangle $2" \times 1\frac{1}{2}"$. The top view, or plan

$F E B A$, is next drawn; this is a rectangle $1\frac{1}{2}'' \times \frac{3}{4}''$, the side $A B$ being the projection of the front of the prism, and the side $F E$ of its back. Lastly, the side elevation is drawn; this is another rectangle $B E H D$, $2'' \times \frac{3}{4}''$, the side $B D$ representing the projection of the front of the prism, and the side $B E$ corresponding to the right-hand end $B E$ of the plan.

Fig. 2 is a **wedge** standing on one of its triangular ends. It is the rectangle shown in Fig. 1, cut diagonally through the corner from E to A on the plan. It will be noticed that the two elevations are exactly the same as in Fig. 1, the plan showing the difference between the two figures.

Fig. 3 is another wedge, standing on one of its rectangular sides, formed by cutting through the prism, in Fig. 1, from A to D . The plan and side elevation are the same as in Fig. 1. Here, the front elevation shows the difference between Figs. 1 and 3. The point D of the elevation is projected on the plan in the point D , and the point opposite D , perpendicular to the plane of the paper, is the point H , shown in all of the side elevations.

Fig. 4 is also a wedge; it is formed by cutting through the prism in Fig. 1 from B to H . The front elevation and plan are the same as shown in Fig. 1, the side elevation being different. The point H in the side elevation opposite D is here projected in the point H of the plan; the point opposite C in the front elevation, and opposite H in the side elevation, is projected in the point K of the plan, the line $K H$ being opposite $C D$ in the plane of the base.

Fig. 5 shows a **cylinder** $1\frac{1}{4}''$ in diameter and $2''$ long. The side elevation is not given, since all elevations of a cylinder whose bases are perpendicular to its axis are the same. Either view may be drawn first, according to convenience.

Fig. 6 shows a **hexagonal prism** $2''$ long; the distance between any two parallel sides is $1\frac{1}{4}''$. In this case, the plan (a regular hexagon) must be drawn first. It is desired also that two of the parallel sides shall be horizontal. To draw the plan in this position, with the dimensions given, choose

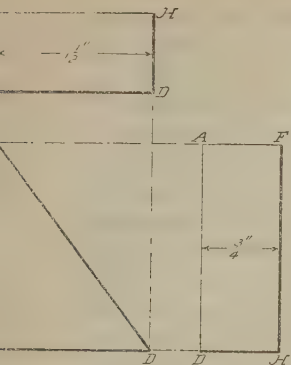


Fig. 3.

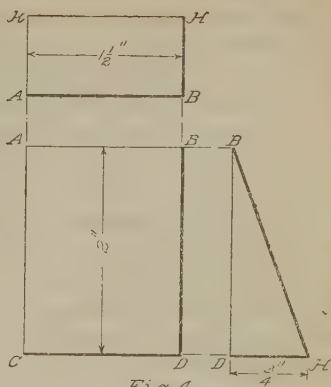


Fig. 4.

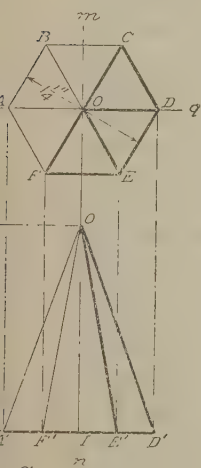


Fig. 7.

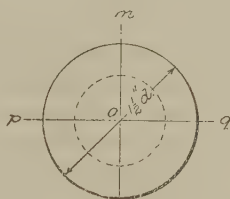


Fig. 8.

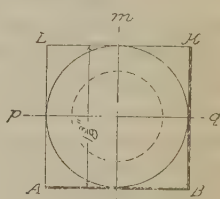


Fig. 9.

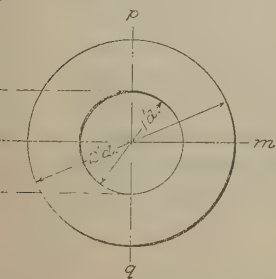
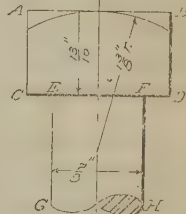
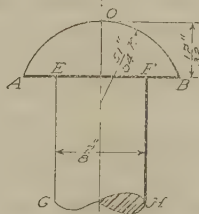


Fig. 11.

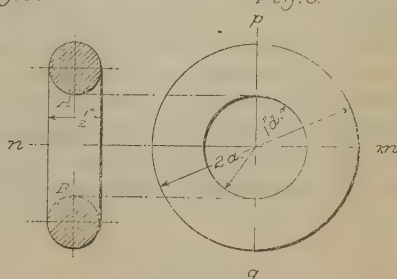


Fig. 12.

the center O of the hexagon; draw two center lines at right angles to each other, as mn and pq . With O as a center, and a radius equal to one-half of the distance between two parallel sides ($1\frac{1}{4}'' \times \frac{1}{2} = \frac{3}{8}''$), describe a circle. Now, use the **T** square to draw two horizontal lines through the points of intersection of this circle with the center line mn . By means of the **T** square and 60° triangle, draw AB and CD through O , in such a manner that the angles AOq and COp each equal 60° ; this is done by keeping the longer of the two short sides of the triangle vertical, and passing the pencil along the hypotenuse. Through E and H , the points of intersection of AB with the two parallel lines, draw EK and HG parallel to CD ; and through F and I , the points of intersection of CD with the two parallels, draw FG and KI parallel to AB . This completes the hexagon, and also the plan of the prism. To draw the front elevation, measure off, on the center line mn , the distance JL equal to $2''$, and through the points J and L draw the two horizontal lines Sc and Rf . Project the points K , I , H , and G upon Sc , as shown by the dotted lines; and, through the points of intersection of these dotted lines with Sc , draw the vertical lines SR , ab , cd , and ef , thus completing the front elevation. To draw the side elevation, extend the lines Sc and Rf , and draw the center line tv . Make UV equal to $1\frac{1}{4}''$, which is equal to the distance between the parallel sides, and draw UX and WY ; also, MZ , the point M corresponding to the point K of the plan.

Fig. 7 represents a **hexagonal pyramid**; the distance between two parallel sides of the base is $1\frac{1}{4}''$, and the altitude is $2''$. As in Fig. 6, the plan must be drawn first. Then, to draw the front elevation, lay off OI on the center line mn equal to the altitude, and through I draw the base line $A'D'$. Project the points D , E , etc. of the plan upon $A'D'$, as shown by the dotted lines, and join them with the point O by the straight lines $A'O$, $F'O$, $E'O$, and $D'O$; these lines are the vertical projections of the edges of the pyramid; the horizontal projections of the edges are FO , EO , DO , etc. The side elevation can be easily drawn, and does not

require a special description, the length of the base BF being equal to the distance between the parallel sides, or $1\frac{1}{4}"$.

Fig. 8 shows a **rivet**, $\frac{7}{8}"$ in diameter, having a button head $1\frac{1}{4}"$ in diameter. The side elevation is not given, since it is exactly the same as the front elevation. Either of the two views may be drawn first, according to convenience. Suppose that the elevation is first drawn. Draw the center line mn , and the line AB for the base of the head. On the center line lay off from the line AB , or the base of the head, a point O , at a distance of $\frac{1}{3}\frac{7}{8}"$, the height of the head. With the compasses set to a radius of $\frac{5}{16}\frac{1}{4}"$, and from a point on the center line mn , describe an arc AOB , taking care to pass this arc through the point O . Lay off from, and on both sides of, the center line mn a distance of $\frac{7}{16}"$, or $\frac{1}{2}$ of the diameter of the rivet, and draw EG and FH . Draw the other center line pq of the plan, and, with O as a center, and a radius equal to the radius of the button head, describe a circle. With the same center, and a radius equal to $\frac{7}{16}"$, describe the dotted circle, the horizontal projection of the rivet. The irregular line GH indicates that only a part of the rivet is shown. This is done so as not to take up too much space on the drawing.

Fig. 9 shows an ordinary **square-headed bolt** $\frac{7}{8}"$ in diameter, having a head $1\frac{3}{8}"$ square and $\frac{1}{16}"$ thick. Draw the center lines mn and pq . Construct the rectangle $ABDC$, $1\frac{3}{8} \times \frac{1}{16}"$, the elevation of the head. Locate the points E and F at a distance of $\frac{7}{16}"$ from each side of the center line, and draw EG and FH . With the compasses set to a radius of $1\frac{3}{8}"$ and from a point on the center line mn , describe the arc representing the chamfering of the head. Draw the plan of the head $LKBA$ (a square whose edge measures $1\frac{3}{8}"$), and the dotted circle $\frac{7}{8}"$ in diameter, the projection of the body of the bolt, which cannot be seen in this view.

Fig. 10 shows a **distance piece** used to separate two other parts, and to keep them a certain distance apart. The arrangement of the views of this figure is somewhat different from the preceding ones, in order to make room for it on the drawing. Draw the center line nm , and construct

the figure according to the dimensions marked on the plate. Use a radius of $\frac{1}{8}$ " for the fillets at *A*, *B*, *C*, and *D*, and an equal radius to round the corners at *E*, *F*, *G*, and *H*.

Fig. 11 shows a **square cast-iron washer**. Instead of making an elevation and plan as usual, a section is taken through *p q*; that is, the washer is imagined to be cut on the line *p q*, with all that part of the figure to the left of *p q* removed, and an elevation drawn of the remaining part. In order to distinguish a sectional drawing without any possibility of mistake, the so-called section lines are employed. These are usually drawn by laying a 45° triangle against the edge of the T square, and drawing a series of parallel lines as nearly equally distant apart as can be judged by the eye. For cast iron, these lines are full, thin lines, all of the same thickness, and must not be drawn too near together. The method of sectioning for other materials will be given later on. It is not usual to draw the section lines in pencil, but to wait until the outlines of the drawing have been inked in, and then section directly with the drawing pen. The shortest distance apart of the section lines should rarely be less than $\frac{1}{16}$ ", unless the drawing is of such small dimensions as to cause a sectioning of this width to look coarse. This is the case with Figs. 11 and 12 of this plate. In these two figures make the section lines a full $\frac{1}{32}$ " apart. Only that part of the figure is sectioned which is touched by the cutting plane, the rest of the figure being drawn as if it were projected upon the cutting plane. The corners of this figure should be rounded with a radius of $\frac{1}{16}$ "; the other dimensions can be obtained from the plate.

Fig. 12 is a **cast-iron cylindrical ring**. It is shown in plan and section. The dimensions given suffice for the drawing of the figure without further explanations. The inner circle of plan is the projection of the innermost points of the ring which form a circle whose diameter is *A B*.

44. When inking in a drawing, it is generally best to draw the circles and other curved lines first, and the straight lines afterwards. This enables the draftsman to easily blend

into one line the straight lines meeting the curves, so that their points of meeting cannot be detected; it enables the tangent lines to be drawn with better success, and also shortens the time of inking in a drawing. It will be noticed that some of the straight lines are heavy and some light, and that parts of the full-line circles are heavy and the rest of the circle light. These are the shade lines; they are described later on. The student may make all of the full lines, except the border lines of this plate and the three following plates, of the same thickness, if he so desires. The dotted lines used to indicate those parts of the figures that are hidden must be of the same thickness as full lines, while the construction lines and center lines should be very thin.

45. Dimensions.—The dimension lines and figures on this and succeeding plates are to be inked in by the student. Make the dimension figures $\frac{3}{8}$ " high, and of the same style as those shown in Art. 20. Fractions should be $\frac{1}{8}$ " high over all. If there is not room for figures of this size, great care should be taken to make them *clear*.

Until after the student has obtained sufficient practice in lettering, he should draw guide lines in pencil for the dimension figures, as in Fig. 69, unless he can make them look

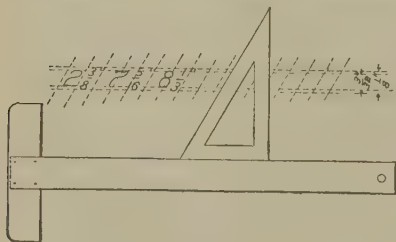


FIG. 69.

well without. All the figures should have the same slant of 60° , and, when printing fractional dimensions, the *whole* fraction should have the same slant as the figures; that is, the denominator should be under the numerator in

a *slanting* direction, and not straight below it. Make the dividing line between the numerator and denominator horizontal, not slanting.

Dimension and extension lines must be light, broken lines

of the same thickness as the center and construction lines. Care should be exercised to make the arrowheads as neatly as possible and of a uniform size. They are made with a Gillott's No. 303 pen, and their points must touch the extension lines, as illustrated in Fig. 70. Do not make arrowheads too flaring.

When putting in the dimensions, care should be taken to give *all* that would be needed to make the piece which the

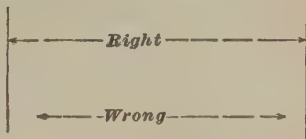


FIG. 70.

drawing represents, but do not repeat the same dimension on different views. Thus, in Fig. 1 of this plate, the length is given in the front elevation as 2", and it is obviously unnecessary to give the same dimension in the side elevation. Again, the dimension lines should be put where they would be most likely to be looked for. In Fig. 10 of this plate, the diameter of the central part of the distance piece is marked $1\frac{1}{4}"$ in the elevation; it could have been marked on the side elevation, as the diameter of the dotted circle, but a person wishing to find the size of this part of the piece would naturally look for it in the front elevation. This is also true of the diameter of the flange. The diameter of the hole could be on the plan or elevation, but it is put on the plan because it is denoted there by a full line, while in the elevation the hole is dotted. Never cross one dimension line by another, if it can well be avoided. Thus, in Figs. 2 and 4 of this plate, the bounding lines of the triangular views are extended by fine broken lines, in order that the dimension lines ($\frac{3}{4}"$) may not cross the lines marking the length and width of the wedge.

The student should ink in all of the figures used for dimensions shown on this and succeeding plates, on his drawing, but should omit the letters used to describe the different objects. The titles should be made in block letters as shown on sample copies. The date, name, course letter, and class number are to be put on as in the preceding plates.

DRAWING PLATE, TITLE: PROJECTIONS—II.

46. The figures on the last plate were drawn under the supposition that the center lines, and at least one flat side, were parallel to the plane of the paper; the center lines were also either vertical or horizontal. This is always possible in detail drawings, where each piece is drawn separately by itself, but in the case of machines, where the parts are placed at different angles, they cannot always be drawn in this manner. The figures on this plate are so drawn that they show objects similar to those in the last plate, but at different angles. The student should exercise particular care to understand this plate and the two succeeding ones; if he thoroughly masters them, he should experience no great difficulty in the plates that follow.

Fig. 1 shows a **rectangular prism** $2\frac{3}{4}$ " long, 2" wide, and 1" thick, standing in a perpendicular position on one of its small ends in such a manner that the broad sides make an angle of 30° with a horizontal line. Draw the plan first. To do this, construct the rectangle $ABCD$ $2" \times 1"$, with the parallel edges AB and DC making an angle of 30° with the horizontal; this may be done by holding the head of the T square against the left-hand end of the board, and using the 60° triangle. To construct the front elevation, draw a horizontal line $A'C'$, and project A upon this line, thus obtaining the point A' . Draw $A'E$ perpendicular to $A'C'$, and make it equal in length to $2\frac{3}{4}"$, the length of the prism. Through E draw EG . Project the points B and C upon $A'C'$, and draw $B'F$ and $C'G$. The back edge $D'H$ of the prism is not seen, and, hence, its position is indicated by the dotted line $D'H$.

The side elevation can be drawn in a similar manner by projecting the points $ABCD$ upon a vertical line, as IL . Produce $A'C'$ and EG , and make $B'D'$ equal to IL . Now use the spacing dividers, and set off $B'C'$ equal to IC , and $B'A'$ equal to IK . Through B' , C' , A' , and D' , draw the vertical lines $B'F$, $C'G$, $A'E$, and $D'H$, drawing $A'E$ dotted, because, when looking at the prism in the direction of the arrow, the edge $A'E$ is not seen.

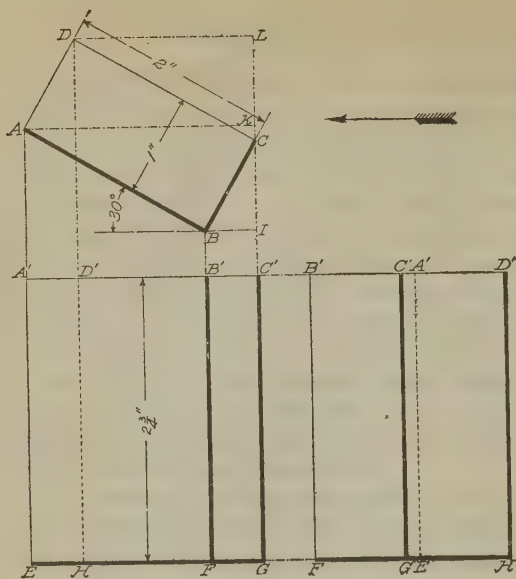


Fig. 1.

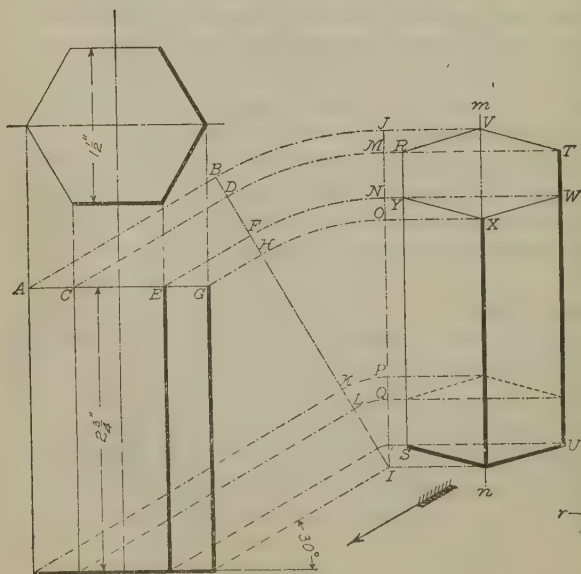
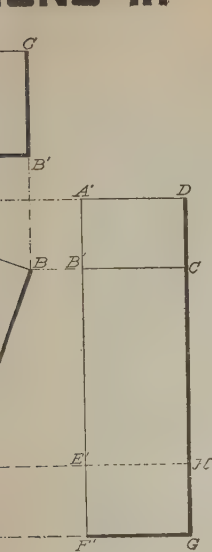


Fig. 4.



IONS-II.



E.

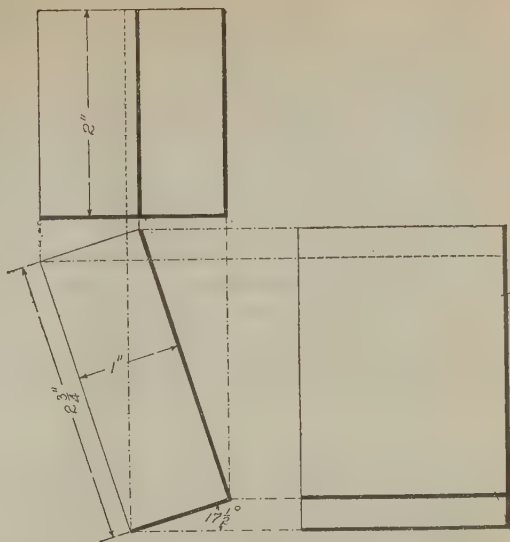


Fig. 3.

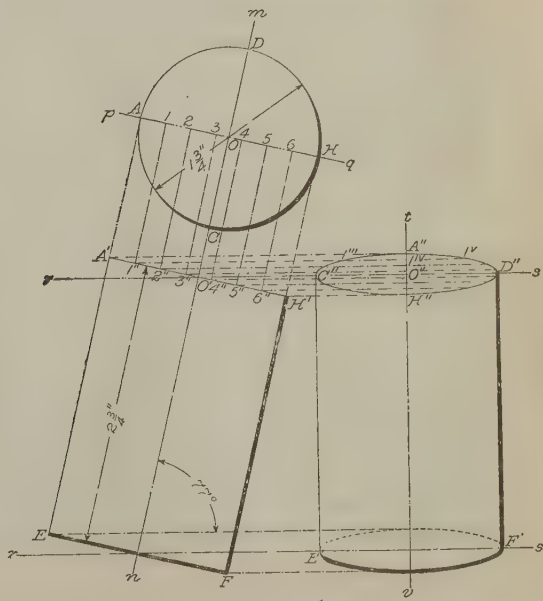


Fig. 6.

Fig. 2 is the same **prism** shown in Fig. 1, but in a different position. The two broad sides are parallel to the plane of the paper, and the prism is tipped in such a manner that the base makes an angle of 160° with the horizontal. The elevation must be drawn first. To do this, draw a horizontal line; then, by using the protractor, draw the line EF , making an angle of 160° with the horizontal, reckoning from right around to the left, opposite to the motion of the hands of a clock. Make EF equal in length to $2''$, and on it construct the rectangle $E F B A$, $2\frac{3}{4}'' \times 2''$; it will be the vertical projection or front elevation of the prism. The method of drawing the plan and side elevation is apparent without further explanation.

Fig. 3 is the same **prism** shown in Figs. 1 and 2, but with the narrow sides parallel to the plane of the paper, and tipped until the base makes an angle of $17\frac{1}{2}^\circ$ with the horizontal. The sizes are the same as in the two preceding figures, and it should be drawn without further explanation, the front elevation being drawn first.

Fig. 4 shows a **hexagonal prism** having two of its parallel sides parallel to the plane of the paper, and its axis vertical; instead of a side elevation at right angles to the horizontal, a side elevation is desired as if the vertical prism were looked at in the direction of the arrow, or at an angle of 30° with the horizontal. Draw the plan first and then the front elevation from the dimensions given. To draw the other view, first draw the center line mn , and then, by use of the **T** square and 30° triangle, draw the lines AB , CD , EF , and GH , from the points A , C , E , and G , as shown. Also draw in a similar manner the other four dotted lines at the base of the prism; then draw the line IB at a right angle to the lines AB , CD , etc. At the point I , draw the line IJ parallel to the center line mn , and, with I as a center, and the points B , D , F , H , K , L , etc. as radii, describe arcs, as shown, cutting the vertical line IJ at the points J , M , N , O , P , Q , etc. Through the points J , M , N , O , P , Q , etc., draw horizontal lines as shown. On each side of the vertical center line mn , lay off a distance of $\frac{3}{4}''$, or one-half the

distance between the parallel sides of the prism, which is $1\frac{1}{2}"$, as shown in the plan, and draw the lines RS and TU . This view is then completed by drawing the lines VR , VT , WX , and YX , as shown. The lines at the base are drawn in a similar manner.

Fig. 5 represents a **hexagonal pyramid** whose axis is parallel to the plane of the paper, the base making an angle of 30° with the horizontal. It is desired to find the vertical projection of the side elevation. Having drawn the plan, $ABCDEF$, and the side elevation, $O'A'B'C'D'$, as shown from the dimensions marked on the drawing, choose the position of the vertical center line tv ; project O' and O''' upon it in the points O'' and O^{IV} , and, through O^{IV} and O''' , draw a fourth center line rs . On this, lay off $O^{IV}G'$ and $O^{IV}H'$ equal to OG and OH , and construct the projection $A''B''C''D''E''F''$, as indicated by the broken and dotted lines. Join $O''E''$, $O''F''$, etc. by straight lines, and it will be the required projection. The figure thus drawn represents the pyramid as it would appear placed so that its base made an angle of 30° with the horizon, the line of vision being horizontal to the observer looking at it from the left side.

Fig. 6 shows a **cylinder** whose axis is parallel to the plane of the paper and makes an angle of 77° with the horizontal. The vertical side projection is required. Draw the plan and front projection as shown from the dimensions given. Draw the center line tv vertical, and project the center O' upon it in O'' ; also, A' in A'' , and H' in H'' . To find the remaining points on the projected circle, divide the diameter AH of the plan into a convenient number of equal parts, in this case 7, as $A1$, $1-2$, $2-3$, etc. Through the points thus laid off, draw the lines $1-1''$, $2-2''$, $3-3''$, etc., parallel to the center line mn . Through the points A' , $1''$, $2''$, $3''$, etc., draw the horizontal lines as shown by the dotted lines. From and on each side of the vertical center line tv , lay off distances on each side of the horizontal lines just drawn equal to the length of that part of the lines $1-1''$, $2-2''$, $3-3''$, etc. included between the center line pq and

the semicircle ACH ; thus, on the horizontal line drawn through the point O' , the distances $O''C''$ and $O''D''$ are each equal to OC in the plan. The distances $I^{IV}I^{'''}$ and $I^{IV}-I^V$ are each equal to the distance from I to the point of intersection of the semicircle on the line $I-I''$. The remaining distances are laid off in a similar manner. A curve traced through the points thus found will be the required projection of the upper base of the cylinder. The projection of the lower base is found in exactly the same way. Drawing $C''E'$ and $D''F'$ completes the required projection.

DRAWING PLATE, TITLE: CONIC SECTIONS.

47. This plate shows the different forms of the curves formed by the intersection of a cone or cylinder by a plane. If the plane of intersection is perpendicular to the axis of the cone or cylinder, the curve of the intersection will be a circle; but, if it is inclined to the axis, it will be an ellipse in the case of a cylinder, and an ellipse, hyperbola, or parabola in the case of a cone, according to the angle of inclination.

Fig. 1 is a **cone cut by a plane** which does not intersect the base of the cone. *When the cutting plane does not intersect the base*, no matter how much the cone may be extended, the curve of intersection is an **ellipse**.

Draw the plan and front elevation of a right cone whose altitude is $3\frac{3}{8}"$, and whose base is $3"$ in diameter. Cut this cone by a plane ab , making an angle of 52° with the base. See figure.

Divide the circle which represents the base of the cone in the plan into any number of parts, in this case 24, and, through the points of division A, E, H , etc., draw the radii OA, OE, OH , etc. to the center O . Draw also from these points straight lines AA', EE', HH', BB' , etc., parallel to the axis of the cone $O'n$, and cutting the base $A'B'$ in the points E', H' , etc. From these points, draw lines to the apex O' of the cone, and cutting the base $A'B'$ in points

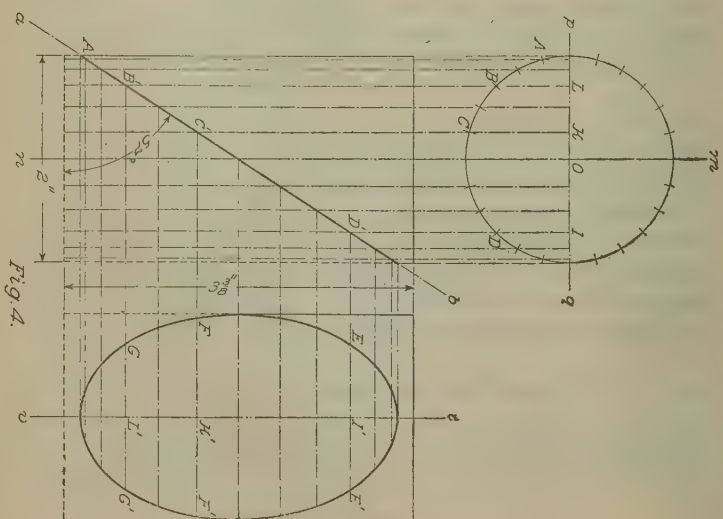
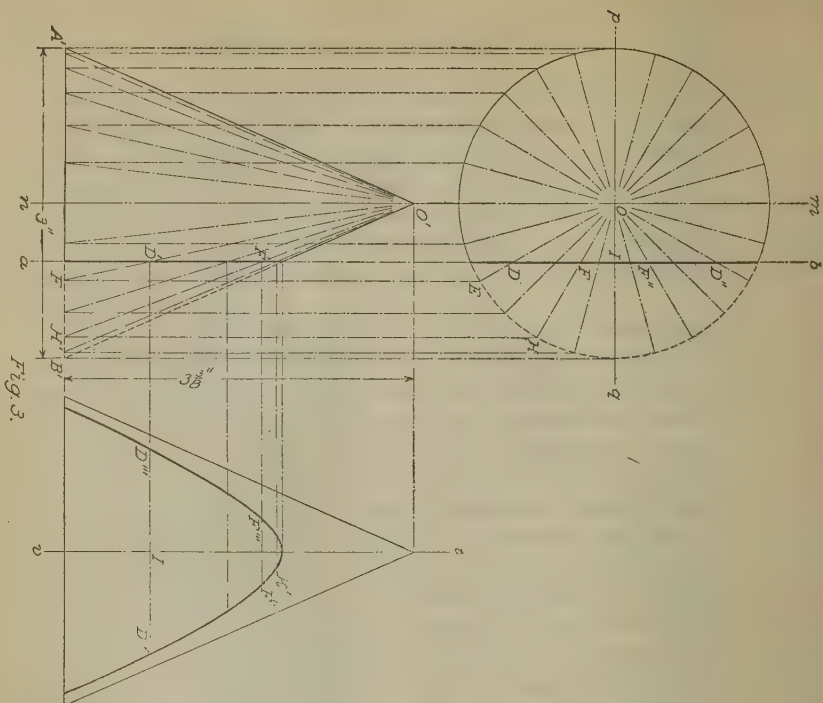
E' , H' , etc. From these points, draw lines to the apex O' of the cone, as $E' O'$, $H' O'$, etc., cutting the plane ab in the points D' , F' , etc. From these points D' , F' , etc., draw straight lines $F' F F''$, $D' D D''$, etc., parallel to the axis $O' n$ of the cone, and intersecting the radii OA , OE , OH , OB , etc. in the points C , D , F , K , F'' , D'' , etc., and through these points of intersection, draw the ellipse by aid of an irregular curve.

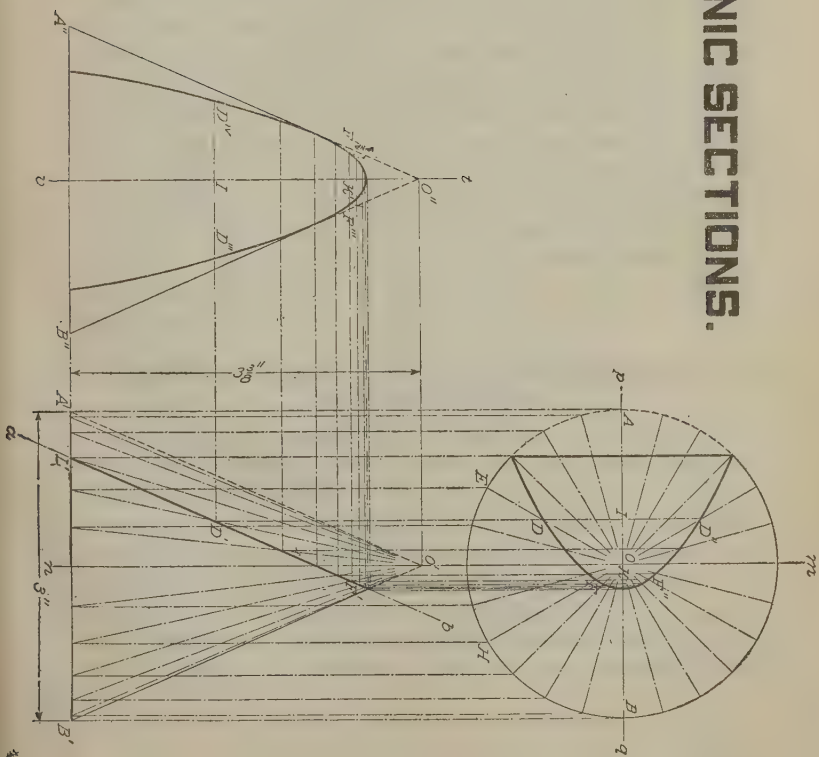
Fig. 2 is a cone of the same size as in the preceding problem; but the cutting plane ab is, in this case, parallel to one of the elements* of the cone, and intersects the base. The curve formed by the intersection of a cone by a plane parallel to one of its elements is called a **parabola**. The plan and front elevations of the cone and curve of intersection are found in a manner similar to the method used in the last problem. To find the side elevation, proceed as follows: Draw the side elevation $O'' A'' B''$ of the cone with the center line tv as its axis. Draw the projection lines $F' F''' F^{iv}$, $D' D''' D^{iv}$, etc., and make $K' F'''$ and $K' F^{iv}$ equal to $K F$ and $K F''$; make $I' D'''$ and $I' D^{iv}$ equal to ID and ID'' , etc., and trace a curve through the points thus found. The result will be the side elevation of the cone when cut by a plane parallel to one of its elements and having the upper part removed. The side elevation of Fig. 1 may be drawn in a similar manner.

Fig. 3 is a cone having the same dimensions as the two preceding problems, but cut by a plane ab parallel to the axis of the cone and perpendicular to the vertical plane of projection. When the cutting plane intersects the base of a cone and is not parallel to any element (that is, if the acute angle included between the cutting plane and the base is greater than the angle $O' A' B'$ included between any one element and the base), the curve of intersection is called a **hyperbola**.

The plan and front elevation are constructed as before, the

* Any straight line drawn on the surface of a cone and passing through the apex (as $O' H'$, Fig. 1, or $O' A'$, Fig. 2, etc.) is called an **element**.





horizontal projection of the curve for this particular case, where the cutting plane is parallel to the axis of the cone, is also a straight line. The side elevation is found as in the last problem, by drawing the lines of projection $I' I''' F^{IV}$, $D' D''' D^{IV}$, etc., and making $I' D'''$ and $I' D^{IV}$ equal to ID and ID'' , $K' F'''$ and $K' F^{IV}$, equal to IF and IF'' , etc. The curve drawn through the points thus found will be the required hyperbola.

Fig. 4 shows the **intersection of a cylinder**, $3\frac{3}{8}"$ long and $2"$ in diameter, by a plane ab , making an angle of 57° with the base. The plan and elevation may be drawn as shown, the horizontal projection of the curve being a circle, having the same diameter as the base. To construct the side elevation of the curve, divide the circle representing the base of the cylinder in the plan into any number of parts, in this case 24, and through the points of division A, B, C , etc., draw the radii OA, OB, OC , etc., to the center O . Draw also from these points straight lines $AA', LB B', KC C', ID D'$, etc., parallel to the axis mn of the cylinder, and cutting the base in the elevation. From the points A, B', C, D' , etc., draw lines $D' E', C' F', B' G'$, etc., at right angles to the axis mn . Make $I' E$ and $I' E'$ each equal to ID ; $K' F$ and $K' F'$ each equal to KC ; $L' G$ and $L' G'$ each equal to LB , etc. The curve drawn through these points will be the side projection, or side elevation, of the curve of intersection.

DRAWING PLATE, TITLE: INTERSECTIONS AND DEVELOPMENTS.

48. On this plate some dimensions are given in decimal fractions instead of common fractions. Such decimal dimensions should be laid off with a decimal scale, if the student has one. A decimal scale is a scale with inches divided into tenths, hundredths, etc. If the student has no decimal scale (and such a scale is not essential), he should take the nearest value of the decimal fraction in thirty-seconds of an inch.

To change a decimal fraction to a common fraction, having a desired denominator, multiply the decimal by the

desired denominator of the common fraction, and express the result as a whole number, which whole number will be the numerator of the fraction.

Thus, to express $.765''$ in fourths, we have $.765 \times 4 = 3.06$ fourths = say $\frac{3}{4}''$. To express $.765''$ in sixteenths, we have $.765 \times 16 = 12.24$ sixteenths = say $\frac{1}{16}''$. To express $.765''$ in thirty-seconds, we have $.765 \times 32 = 24.48$ thirty-seconds = say $\frac{2}{32}''$.

The length of the circumference of a circle = the diameter $\times 3.1416$; hence,

The length of circumference of a circle whose diameter is $1\frac{3}{8}'' = 3.1416 \times 1\frac{3}{8}'' = 4.32'' = 4\frac{5}{16}''$.

The length of circumference of a circle whose diameter is $1\frac{1}{2}'' = 3.1416 \times 1\frac{1}{2}'' = 4.71'' = 4\frac{2}{3}''$.

The length of circumference of a circle whose diameter is $1\frac{1}{4}'' = 3.1416 \times 1\frac{1}{4}'' = 3.93'' = 3\frac{1}{16}''$.

The length of circumference of a circle whose diameter is $1\frac{9}{16}'' = 3.1416 \times 1\frac{9}{16}'' = 4.9''$.

$$4.9'' \div 2 = 2.45'' = 2\frac{7}{16}'' \text{ (see Fig. 10).}$$

49. This plate deals with the intersection of surfaces and their development. Fig. 1 shows the intersection of **two unequal cylindrical surfaces** whose axes pq and mn intersect at right angles. Their dimensions are given in the figure. For the sake of convenience, a bottom view is given, instead of a top view, as usual. First draw the front elevation, omitting, of course, the curve of intersection $E Q G D C B A$, which must be found. Then draw the side elevation and the bottom view, as shown. Divide the circle which represents the side projection of the cylindrical surface $F E A 1$ into any convenient number of parts, in this case 12, and draw the projection lines $7 E$, $6 Q$, $5 G$, $4 D$, $3 C$, $2 B$, and $1 A$ parallel to the axis pq . Also draw the projection lines $4-4'$, $3-3'$, $2-2'$, $1-1'$, etc. parallel to the axis tv . Choose a convenient point O , and through it draw two lines $O I$ and $O K$ parallel to the axes pq and mn of the cylinders. Continue the lines $4-4'$, $3-3'$, etc. downwards, until they cut $O I$ in 8 , 7 , 6 , 5 , etc. Now make $O 8' = O 8$,

INTERSECTIONS A

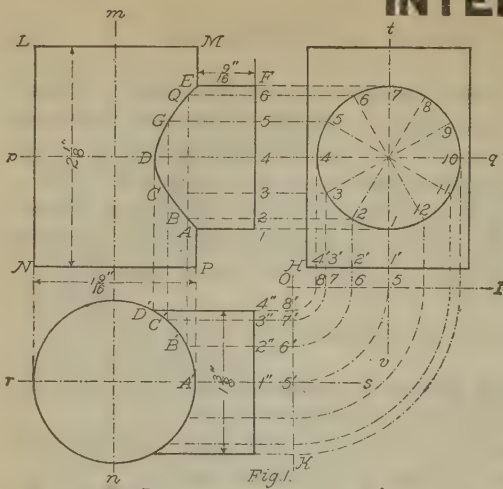


Fig. 1.

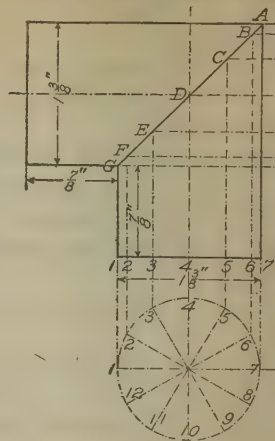


Fig. 2.

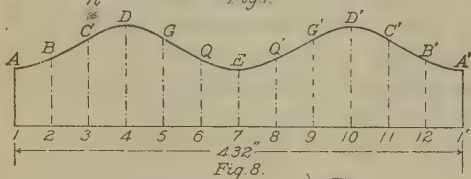


Fig. 8.

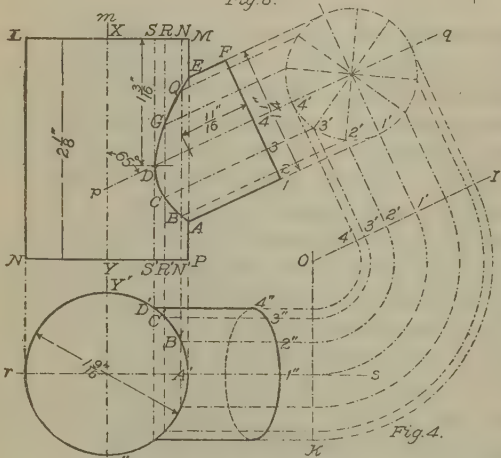


Fig. 4.

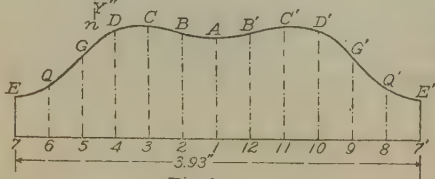


Fig. 9.

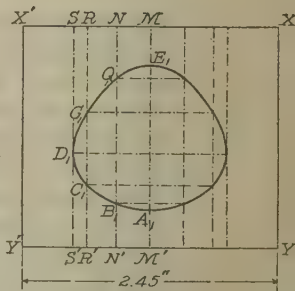


Fig. 10.

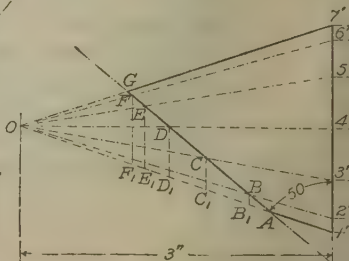


Fig. 1.

DEVELOPMENTS.

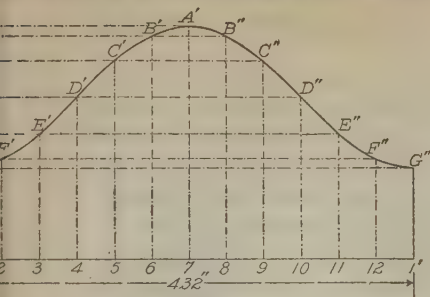


Fig. 6.

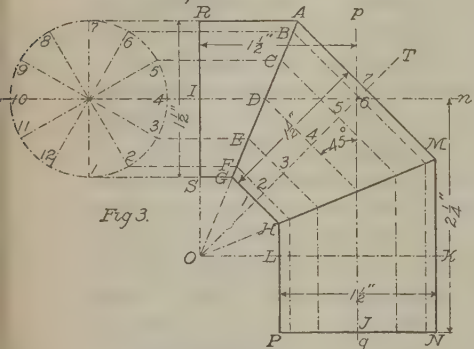


Fig. 3.

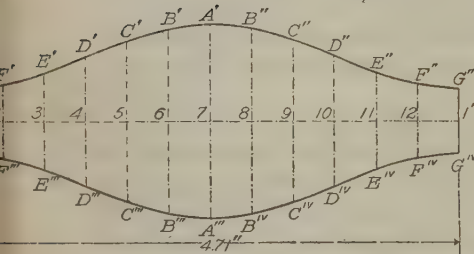


Fig. 7.

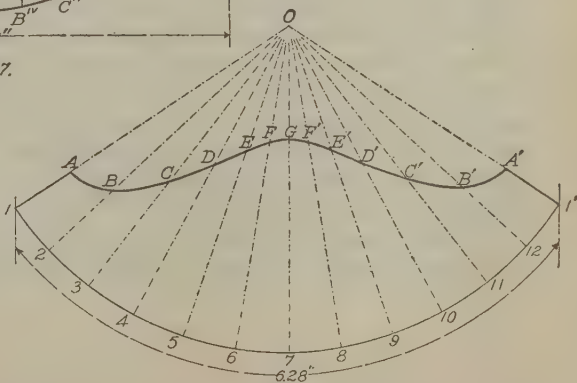


Fig. 12

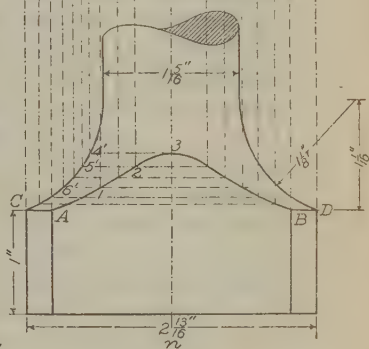
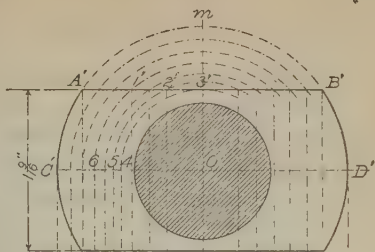


Fig. 5.

$O7' = O7$, etc.; this may be most conveniently done by taking O as a center, and describing arcs of circles with radii equal to $O8$, $O7$, $O6$, etc., cutting OK in $8'$, $7'$, $6'$, etc. Through $8'$, $7'$, $6'$, etc., draw the lines $8'D'$, $7'C'$, $6'B'$, etc., parallel to the center line rs . Through the points D' , C' , B' , and A' , draw the lines $D'D$, $C'G$, and $B'Q$, parallel to the center line mn , and intersecting the lines $4D$, $5G$, $6Q$, $3C$, and $2B$ in the points D , G , Q , etc. The curve traced through these points will be the front elevation of the curve of intersection of the two cylindrical surfaces.

Fig. 2 shows the intersection of **two equal cylindrical surfaces** at right angles to each other, as in the case of a pipe elbow. When two cylinders having *equal diameters intersect, and their axes also intersect*, the front elevation of the curve of intersection is always a straight line, no matter what angle the two axes make with each other.

Fig. 3 shows a symmetrical **three-jointed elbow** formed by the intersection of three cylindrical surfaces. The diameter of each of the three surfaces is $1\frac{1}{2}"$. The center lines of the surfaces $RAGS$ and $MNPH$ are to be at right angles to each other; then, in order that the arrangement shall be symmetrical, the center line of the third surface $AMHG$ must make an angle of 45° with the center lines of the other two.

To construct the elevation as shown in the figure, draw the two center lines mn and pq at right angles to each other; they intersect at 6 . Lay off $6I = 1\frac{1}{2}"$ and draw an indefinite line RS through I perpendicular to mn . Make IR equal to $IS = 1\frac{1}{2} \times \frac{1}{2} = \frac{3}{4}"$, and draw RA and SG parallel to mn . Draw OK parallel to mn and $1\frac{1}{2}"$ below it. Through the point O , where RS and OK intersect, draw OT passing through 6 , and bisect the angle ROT by the line OA , which intersects RA and SG in A and G . Lay off $6J = 2\frac{1}{4}"$ and draw PJN perpendicular to pq . Make $JP = JN = 1\frac{1}{2} \times \frac{1}{2} = \frac{3}{4}"$, and draw PH and NM parallel to pq . Draw OM so as to bisect the angle TOK ; OM intersects PH and NM in H and M . Finally, draw AM and GH .

Fig. 4 shows the intersection of **two unequal cylindrical surfaces** whose axes intersect at an angle of 65° instead of 90° , as in Fig. 1. The method of finding the curve of intersection is in all respects similar to that used in Fig. 1, and, as the corresponding points have been given the same letters or figures, the directions given for Fig. 1 can be applied to Fig. 4 also.

Fig. 5 shows a **cylindrical piece of iron** $2\frac{1}{16}$ " in diameter that has been gradually turned down to $1\frac{5}{16}$ " diameter, and then having the larger part flattened on two sides. The large and small parts of the piece are connected by a graceful curve. The problem is to find the curve of intersection $A123B$ formed by the flattening. Draw the plan and front elevation from the dimensions given; also draw the curve $C6'5'4'$, and its equal on the opposite side, so that they look to the eye about as seen in the drawing. In order that all the work sent to us may be alike, the radius of this curve and the position of the center have been given on the drawing. To locate the center, draw an indefinite horizontal straight line, $1'' + 1\frac{1}{16}'' = 2\frac{1}{16}''$ above the base of the piece; and with C and D as centers, and a radius of $1\frac{1}{8}''$, describe short arcs cutting the line just drawn. The points of intersection will be the required centers. With O as a center, and radii of convenient lengths, as $O4$, $O5$, $O6$, etc., describe arcs cutting $A'B'$ in $3'$, $2'$, $1'$, etc. Through the points 4 , 5 , 6 , etc., draw the lines $4-4'$, $5-5'$, $6-6'$, etc., parallel to the center line mn , and intersecting the curve $C4'$ in $4'$, $5'$, $6'$, C , etc. Through the points A' , $1'$, $2'$, etc., draw lines $A'A$, $1'-1$, $2'-2$, etc., parallel to mn intersecting horizontal lines drawn through C , $6'$, $5'$, $4'$, etc., in A , 1 , 2 , 3 , etc. The points A , 1 , 2 , 3 , etc. are points on the required curve, and through them the curve may be drawn.

Fig. 6 is the **cylindrical surface** of one section of the elbow $17AG$ of Fig. 2 rolled out into a flat plate; hence, if a flat plate be cut into the same shape and size as Fig. 6 and bent into a cylinder so that the ends $1G'$ and $1'G''$ touch each other, the vertical projection or front elevation would be the same as shown by $17AG$ in Fig. 2. If a second

plate were cut out in the same manner, and bent into a circle, the two pieces on being brought together, as shown in Fig. 2, would touch at every point. The problem is to find the shape of the curve $G'A'G''$. The length of the line $1-1'$ is evidently equal to the length of the circumference of a circle whose diameter is $1\frac{3}{8}"$, or $4.32"$, very nearly. Produce the line $1-7$, Fig. 2, and make $1-1'$ equal in length to $4.32"$. Divide the circle $123 \dots 12$ into a convenient number of equal parts, in this case 12, and erect the perpendiculars $1G, 2F, 3E$, etc., cutting the line of intersection GA of the cylindrical surfaces in G, F, E , etc. Divide the line $1-1'$ into the same number of equal parts that the circle was divided into, thus making the length $1-2$ equal length of arc $1-2$; $2-3$, length of arc $2-3$, etc. Through $1, 2, 3$, etc., draw the perpendiculars $1G', 2F', 3E'$, etc., and project the points G, F, E , etc., upon these perpendiculars, as shown, thus locating the points $G', F', E', D', C', B', A'$ of the left-hand half of the required curve. The points on the right-hand half are found in the same manner, as shown, and the required curve can be drawn through these points.

50. A drawing like Fig. 6 is called the **development of the cylindrical surface** $17AG$.

Fig. 7 is the **development of the cylindrical surface** $AGHM$ of Fig. 3. Make $1-1' = 1\frac{1}{2} \times 3.1416 = 4.71"$, nearly, and divide it into 12 equal parts to correspond with the 12 equal parts into which the dotted circle is divided. Project the points $6, 5$, etc., of the dotted circle upon OA as shown, thus locating the points B, C , etc. Through B, C , etc., draw $B6, C5$, etc., perpendicular to OT . Make $1G' = 1G''' = 1G, 2F' = 2F''' = 2F, 3E' = 3E''' = 3E$, etc. Through G', F', E' , etc., trace the curve $G'F'E' \dots G''$, and, through G''', F''', E''' , etc., trace the curve $G'''F'''E''' \dots G^{iv}$. Drawing $G'G'''$ and $G''G^{iv}$ completes the figure.

Fig. 8 is the development of the cylindrical surface $1FEA$, Fig. 1. The method used here is in all respects similar to the two preceding problems. In this case, the distances

$1A$, $7E$, and $1'A'$ are all equal to $1A$ or EF , in Fig. 1; and $2B$, $6Q$, $8Q'$, and $12B'$ are all equal to $2B$ or $6Q$, in Fig. 1. The development of $LMPN$ is not given, for want of room, but the method will be explained in Fig. 10.

Fig. 9 is the development of the cylindrical surface $1FEA$, Fig. 4. The student should have no difficulty in drawing this, after having studied the preceding problems.

Fig. 10 is the development of the cylindrical surface $LMPN$, Fig. 4. Owing to the want of room, only that half of the development is shown which contains the part to be cut out. The length of a circle $1\frac{9}{16}$ " in diameter is 4.9 ", nearly; half of this is 2.45 ". Hence, the line $Y'Y''$, Fig. 10, which equals the length of the semicircle $Y'A'Y''$, Fig. 4, is 2.45 " long. The distance $X'Y' = X''Y''$ equals the length of the cylinder, LN or MP . Lay off $X'S$ equal to the length of the arc $Y'D'$; SR equal to the arc $D'C'$; RN equal to the arc $C'B'$; NM equal to the arc $B'A'$, etc. Find the lengths of these arcs by means of the method given in connection with Fig. 49. Draw through these points the perpendiculars SS' , RR' , etc. With the spacing dividers, set off SD_1 equal to SD in Fig. 4; RG_1 equal to RG ; NQ_1 equal to NQ ; and ME_1 equal to ME . Also, $R'C_1$ equal to $R'C$; $N'B_1$ equal to $N'B$; and $M'A_1$ equal to PA . In exactly the same manner, find the points on the right-hand half of the curve. If a plate were cut of the same size and shape as shown in Fig. 10, and rolled into a semicylindrical surface, the diameter of which is $1\frac{9}{16}$ ", it would exactly fit the plate cut like Fig. 9 rolled into a cylindrical surface, the diameter of which is $1\frac{1}{4}$ ", the two being placed together as shown in Fig. 4.

Fig. 11 shows a **conical surface cut by a plane**, and Fig. 12 shows its **development**. Draw the elevation and horizontal projection of the base as shown in Fig. 11. Divide the projected circle (base of cone) into a convenient number of equal parts, in this case 12, and project the points $1, 2, 3$, etc. on the base $1'-7'$, thus locating the points $1', 2', 3'$, etc. Join these points with the apex O of the cone, by the lines $O1', O2', O3'$, etc., cutting the plane in A, B, C , etc. Now,

choose a convenient point O , Fig. 12, and with this as a center, and a radius equal to $O I'$, or $O \gamma'$, Fig. 11, the slant height of the cone, describe an arc $I-I'$ of a circle. Make the *length of this arc* equal to the length of the circumference of a circle having the same diameter as the base of the cone. This may be conveniently done as follows: length of arc $= 2 \times 3.1416 = 6.28''$, nearly. Draw a straight line $6.28''$ long and divide it into, say, 4 equal parts. Describe an arc having a radius equal to $O I'$, the slant height of the cone, and find the length of a part of this arc equal to $6.28 \div 4 = 1.57''$ by means of the method described in connection with Fig. 48. With the dividers set for the chord of the arc just found, space off the chord four times on the longer arc $123 \dots I'$, Fig. 12. Divide the arc into the same number of equal parts that the circle $123 \dots 12$ has been divided into, that is, 12 parts. Join the points of division $1, 2, 3$, etc., with the center O by the lines $O 1, O 2, O 3$, etc., as shown. Project the points B, C, D , etc., Fig. 11, upon $O I'$, in B_1, C_1, D_1 , etc., as shown, and lay off $O A$ equal to $O A'$ equal to $O A$, Fig. 11; $O B$ equal to $O B'$ equal to $O B_1$; $O C$ equal to $O C'$ equal to $O C_1$, etc., and through these points draw the curve. A plate cut of the same size and shape as shown by $A G A' I' \gamma 1$ can be bent into the conical surface shown by the elevation $A G \gamma' I'$.

Particular attention must be given to the method explained above for laying out the curve of the development in Fig. 12. It would be entirely wrong to take the measurements from the lines $O F, O E, O D, O C$, etc., Fig. 11. The reason for this is that these lines, being on the surface of the cone, are inclined toward the observer, and so do not appear in their true length. The line $O D$, for example, if measured on the surface of the cone itself, would evidently be of the same length as the line $O D_1$; but, in the figure, it is much shorter. The line $O D_1$, however, appears in its true length in the figure, because it is not inclined to the observer in the position shown. The actual distance of point D from the apex O , therefore, is $O D_1$, which is the distance to be laid off for point D in the development. The same holds true for the other points.

SHADE LINES.

51. The use of the heavy shade line will now be explained. In Fig. 71, by means of the shade lines, the draftsman knows, without looking at any other view of the object, that the rectangles 1 and 4 represent square holes, and 2 and 3, square bosses. When he looks at the other view, it is to find the depth of the holes and the height of the bosses. This explains the use of the shade lines, viz.: to show, from that view of the drawing which is being examined, whether the part looked at is above or below the plane

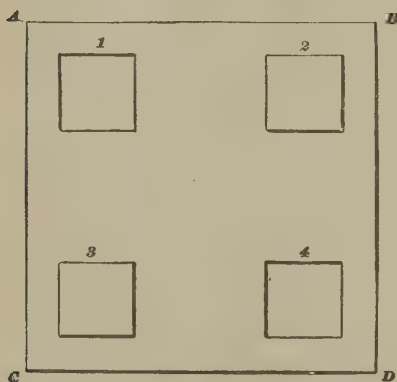


FIG. 71.

of the surface; that is, for example, whether the rectangles 1, 2, 3, and 4 are the tops of bosses or bottoms of holes, and, consequently, whether they extend above or below the surface of $ABDC$. In order that the shading may be uniform on all drawings, the light is assumed to come in one invariable direction, in such a manner as to be

parallel to the plane of the paper, to make an angle of 45° with all horizontal and vertical lines of the drawing, and to come from the upper left-hand corner of the drawing. Each view of the object represented is shaded independently of any of the others; and, when shading, the object is always supposed to stand in such a position that the drawing will represent a top view. Any surface that can be touched by drawing a series of parallel straight lines, making an angle of 45° with the horizontal and vertical lines of the drawing, is called a **light surface**; a surface that cannot be touched by lines having this angle is called a **dark surface**. All of the edges caused by the intersection of a light and dark surface, or two dark surfaces, are usually shaded; that is, the edges

thus formed are drawn in heavy lines. Exceptions to this rule are sometimes made by experienced draftsmen, when a rigid adherence to it will produce a bad effect or will render the drawing ambiguous.

Fig. 72 shows a plan of a series of triangular wedges radiating from the common center O . The top is, of course, a light surface, and, in order to determine whether the perpendicular surfaces are light or not, the 45° triangle may be used. Take the wedge ROA . A line drawn at an angle of 45° , the direction of the arrows, would strike the side of which OA is the edge; hence, this side is a light surface, and the top being also a light surface, the line OA must be light. OR , on the contrary, is a heavy line, since the light cannot strike the side of which OR is the edge without passing through the wedge. Hence, this is a dark surface, and its intersection OR with the light surface OAR requires a shaded line. For the same reason, AR is also shaded.

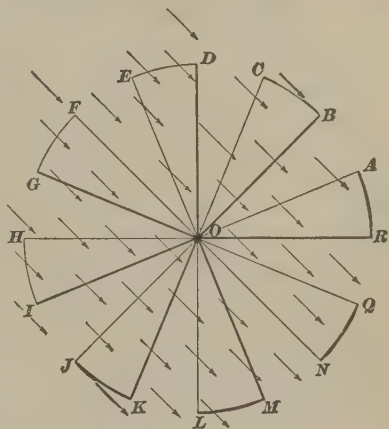


FIG. 72.

The same reasoning as the above applies to the lines OB , OD , OG , OI , OK , and OM ; also, to QN , ML , and KJ . CB is not shaded, because the light strikes the surface of which CB is the edge, as shown by the arrow, making CB the intersection of two light surfaces. ON makes an angle of exactly 45° with the horizontal, and is treated as if it were the edge of a light surface; this is done in every case in which the line considered makes an angle of 45° with the horizontal.

In shading holes, or any parts of the drawing denoting depressions below the surface under consideration, a slightly

different assumption is made. Fig. 73 shows the plan of a square block with a hexagonal hole in the center. If the light passed over the surface $ABCD$, parallel to the plane

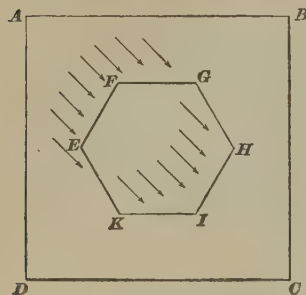


FIG. 73.

of the paper as previously assumed, all of the inside surfaces would be dark, and the entire outline of the hexagon $EFGHIK$ would be shaded. In order to prevent this and make the work similar to that which has preceded, the rays of light are assumed to make an angle of 45° with the plane of the paper when shading holes and depressions. Hence, the

light will strike the surfaces whose edges are GH , HI , and IK , as shown by the arrows, leaving the surfaces whose edges are KE , EF , and FG dark as before. Therefore, these latter edges will be shaded, and the edges GH , HI , and IK will be light. See also Fig. 71.

The conventional method of shading circles which represent the projections of cylinders, or circular holes, is as follows: AB , Fig. 74, is the projection or end view of a cylinder having for a base the circular area AB . Draw the arrows EA and FB , making angles of 45° with the horizontal diameter, and tangent to the circle at A and B . That half of the circle in front of these two points of tangency is to be shaded, and, in order to

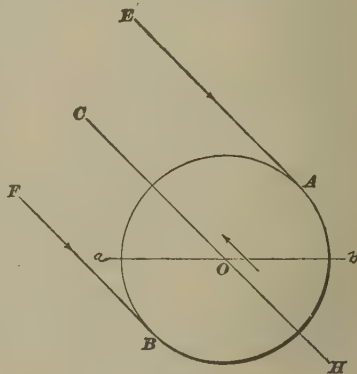


FIG. 74.

make the drawing look well, the center point for the compasses is shifted along the line CH parallel to EA and FB

in the direction of the arrow an amount equal to the thickness of the desired line. With the same radius that was used to describe the original circle, describe part of another circle, being careful not to run over the first circle, and stopping when the two lines coincide. The directions for shading a hole are precisely the same as for the projection of a cylinder base, except that the half BCA of the circle in Fig. 75 is to be shaded, the center being shifted as before, but in the opposite direction, as shown by the arrow.

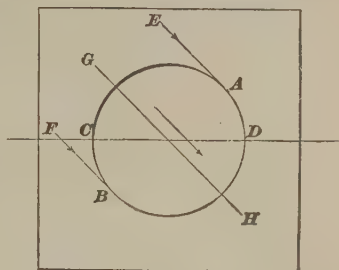


FIG. 75.

Vertical projections of cylinders are shaded as shown in the front elevation of Fig. 5, Drawing Plate, title: Projections I.

After studying the foregoing concerning shade lines, the student should be able to see the reason for the using or omitting of any shade lines on the drawings in the following plates. In the case of an object like the hexagonal prism in Fig. 6, Drawing Plate, title: Projections I, no part of the upper base or line Se is shaded, although, strictly speaking, the part ce of the line should be shaded; but, as this would make part of the straight line Se heavy and the greater part light, the whole line is drawn light. This is one of the exceptions previously mentioned.

ARCHITECTURAL DRAWING

INTRODUCTION

1. Architectural drawing includes both instrumental and freehand drawing, the latter being of the class known as ornamental drawing. The first constitutes the larger part of architectural drawing, and consists of straight and curved line work executed entirely with the instruments. The second is made up largely of curved-line work done freehand, although occasionally an irregular curve may be found useful.

In this section on *Architectural Drawing* the student will meet with architectural subjects that require no freehand drawing, except, in a few instances, to a limited extent. The drawing plates in this section are to be the same size as those in *Geometrical Drawing*, viz., 13 in. $\times$ 17 in. inside the border lines. No part is to be drawn nearer than $\frac{3}{4}$ inch to these lines, and no part of a drawing is to be inked in before the whole plate has been finished in pencil, as was explained in *Geometrical Drawing*. The student should show all the dimensions and dimension lines, also the shade lines and headings, when they occur, but he need not put in the letters of reference. Before proceeding with the drawing of the plates, we will first describe the use of the scales which are used to determine the relative proportions of the drawing.

SCALES

2. When a drawing is made to represent any object, so that the size of any part of that object may be measured from the drawing, the representation is said to be "drawn

§ 14

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FIG. 1

to scale," no matter whether it is drawn full size of the original, or some definite fractional size. In order to make these drawings, an instrument called a "scale" is used to lay off the dimensions, so that they shall bear a uniform proportion to one another. To make a full-sized drawing, a scale, divided into inches and fractions of an inch, is used; but to make a half-sized drawing, a scale is used on which each 6 inches of its length is divided into twelve parts, each division being considered as 1 inch. In the same manner, a quarter scale has each 3 inches divided into twelve parts, and so on down to the scale of $\frac{1}{8}$ inch to a foot, where each $\frac{1}{8}$ inch of the scale represents 1 foot in length, and is divided into twelve parts to indicate the inches. This is the smallest scale ordinarily used in architectural work.

Fig. 1 of the text shows a scale which is convenient for the student, since it combines eleven different systems of subdivision, and may be used to lay out all the work in this course in drawing. This scale is triangular in section and 12 inches in length, and on each of its edges is laid off a scale, as shown at *A*, *B*, and *G*. The scale at *G* is "full size"; that is, this edge of the scale is divided into inches and fractions of an inch, down to sixteenths, and is used for drawings that are the full size of the original. On the opposite side, at *B*, is shown the quarter-sized scale of 3 inches to 1 foot. The first 3-inch division, from *B* to *C*, is subdivided into twelve parts representing inches, and each inch is then divided into proportional fractions of an inch. From *C* to *D*, *D* to *E*, and *E* to *F* the scale is marked in its main divisions of 3 inches each. From *A* to *B* the scale is independently divided into spaces of $1\frac{1}{2}$ inches each,

to form an eighth-sized scale, or $1\frac{1}{2}$ inches to the foot, the divisions of the latter occurring on and between the marks for the 3-inch scale.

The other sides and edges of the instrument are divided into scales of 1 inch and $\frac{1}{2}$ inch, $\frac{3}{4}$ inch and $\frac{3}{8}$ inch, $\frac{1}{4}$ inch and $\frac{1}{8}$ inch, and $\frac{3}{16}$ inch and $\frac{3}{32}$ inch, respectively, making, with the full-sized scale at *G*, eleven in all. It will be observed that the numbering of the feet on these scales does not start at the end of the instrument, but at the first division from the end. As on the quarter-sized scale, the zero mark is placed at *C* and the first foot is measured to *D*. This is done so that the feet and inches may be laid off independently, and with one reading of the scale.

The figures indicating the number of feet on this scale are placed along the extreme upper edge at *D*, *E*, and *F*, to the right of the zero mark *C*; and those indicating inches, to the left of the zero mark. To lay off 2 feet $3\frac{3}{4}$ inches from a given point, place the scale on the point so that the 2-foot mark will be directly over it; then, from the zero mark *C* lay off $3\frac{3}{4}$ inches, as shown, locating a second point. The length of the distance thus laid off between the two points represents 2 feet $3\frac{3}{4}$ inches. The same remarks apply to the other scale of $1\frac{1}{2}$ inches to the foot, and the figures indicating feet on this scale are placed nearer the edge of the scale, in order to prevent confusion in reading.

To draw to a scale of half size, or 6 inches to the foot, use the full-sized scale, and remember that every $\frac{1}{2}$ inch equals 1 inch on the object; that is, that every dimension is only one-half the real length. To lay off $5\frac{7}{8}$ inches, first lay off 5 half inches and then $\frac{7}{16}$ inch over. The result is a distance of $5\frac{7}{8}$ inches to a scale of half size, or 6 inches to the foot.

In all kinds of architectural drawing, the smaller scales are used more frequently than the larger ones, and it is customary to speak of them as $\frac{1}{4}$ scale, $\frac{1}{8}$ scale, etc. when scales of $\frac{1}{4}$ inch or $\frac{1}{8}$ inch to the foot are meant. The student must therefore be careful not to confuse these expressions with the $\frac{1}{4}$ size and $\frac{1}{8}$ size, which refer to scales of 3 inches and $1\frac{1}{2}$ inches to the foot, respectively.

It sometimes happens that a draftsman is obliged to make a scale when the size of his drawing paper is limited and a general drawing of some object is desired. By **general drawing** is meant a complete view of the object in plan and one or two elevations. In such a case, one scale may be too large to enable a drawing to be made on a single sheet of the required size. Another scale may make it too small to show it up well. For example, where a $\frac{1}{4}$ scale may be too large, a $\frac{1}{8}$ scale may be too small, and a $\frac{1}{6}$ scale may be just right. If the draftsman has no $\frac{1}{6}$ scale (that is, a scale of 2 inches to the foot), he may make one by taking a piece of heavy drawing paper and cutting out a strip about the size of an ordinary scale and laying off the 2-inch divisions on it. Each division or part will represent 1 foot of the object. Divide one of the end divisions into twelve equal parts, and each will represent 1 inch of the object. Lines indicating half inches and quarter inches may be drawn, if considered necessary.

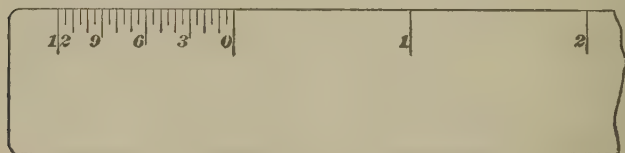


FIG. 2

In Fig. 2 of the text is shown part of a scale made in this manner, giving feet, inches, and half inches, the quarters, eighths, etc. of an inch being judged by the eye.

DRAWING PLATE, TITLE: MOLDINGS

3. This plate represents a series of architectural moldings, and demonstrates a method by which each may be geometrically drawn.

Fig. 1 shows a torus molding, which is half round, and here shown between two fillets.

Fig. 2 shows a cavetto, or cove, with fillets.

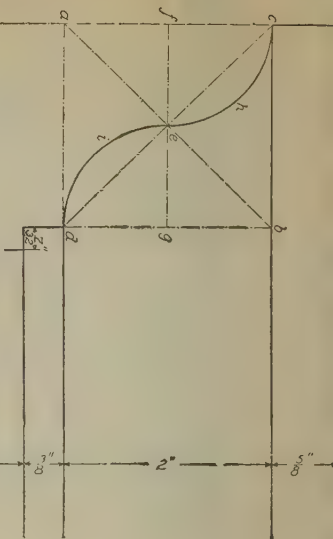


Fig. 3.

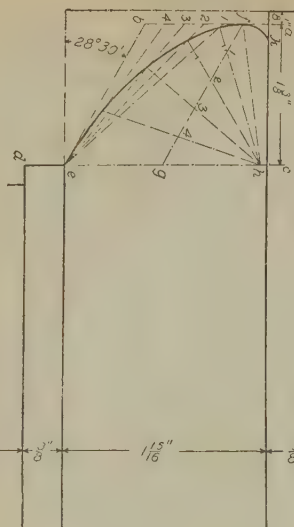


Fig. 4.

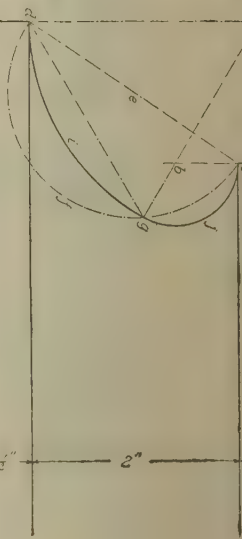


Fig. 7.

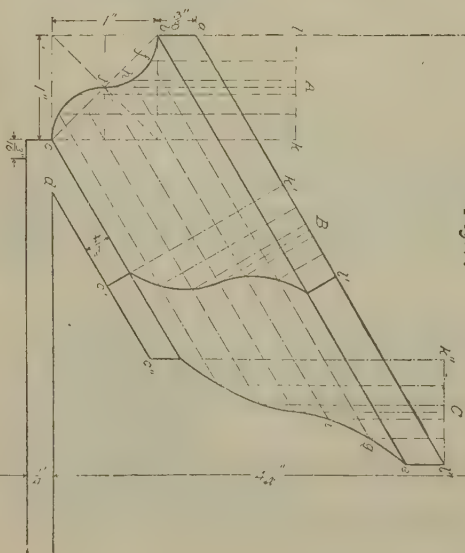


Fig. 8.

MOLDINGS.

Scale Full Size.

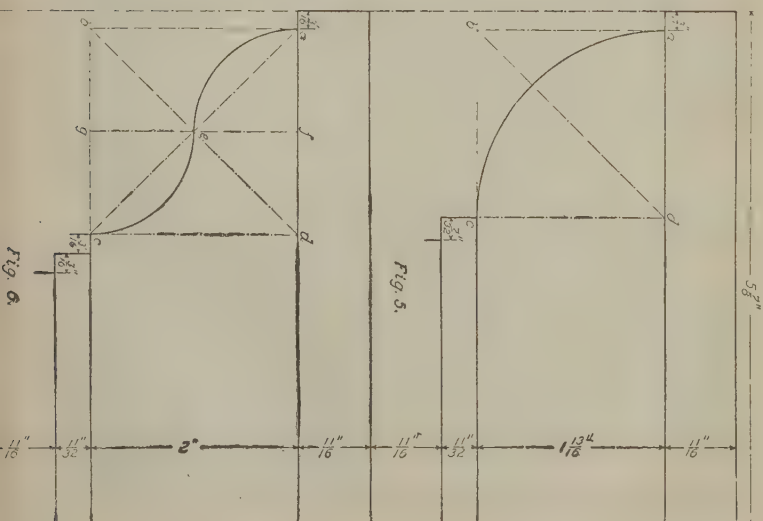
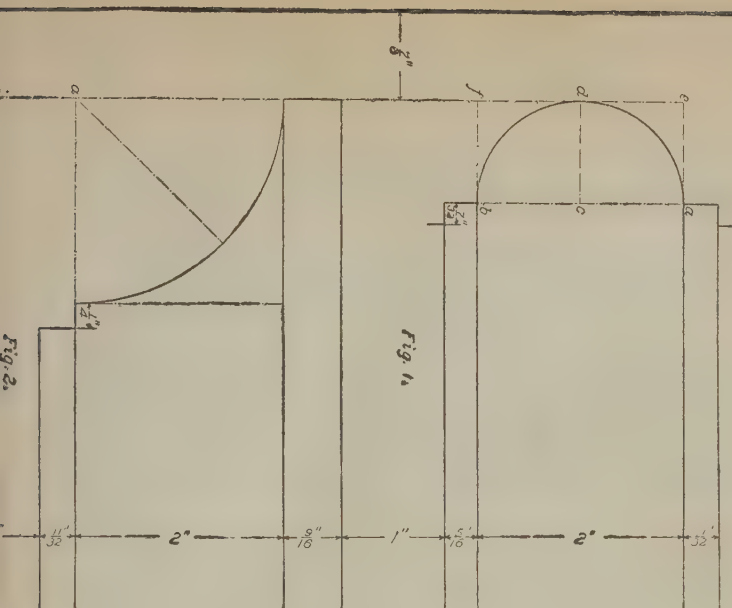


Fig. 3 shows a cyma recta, with fillets.

Fig. 4 shows an echinus, with fillets.

Fig. 5 shows a quarter round, sometimes termed an *ovolo*, with fillets.

Fig. 6 shows a cyma reversa, with fillets, which, with the cyma recta shown in Fig. 3, is usually called an *ogee*.

Fig. 7 shows a scotia, with fillets.

Fig. 8 shows the method of developing a raking crown molding of the cyma-recta type, with its accompanying fillets. The fillets are the narrow, square-edged pieces, above and below each molding, which are not included as a part of the molding itself, though they usually accompany it in order to clearly define the point where its curvature starts.

To draw this plate, mark off from the left-hand border line $\frac{7}{8}$ inch, and from the right-hand border line $5\frac{7}{8}$ inches, and through each of the points so located draw a vertical construction line full length of the plate. Then, from the lower border line, lay off the points that locate the horizontal lines of the fillets, and through these points draw the fillets, extending them to the vertical lines first drawn.

In Fig. 1, at a distance of $1\frac{7}{8}$ inches from the left-hand border line, draw the dotted line ab ; bisect it at c , and from c as a center, with a radius ac , describe the semi-circle adb , which is the convex outline of the member termed a *torus*. Then, from a and b , draw the short vertical lines that close the ends of the fillets.

A collar member, fulfilling a function similar to that of the torus, may be formed by a square-edged band instead of a half round, as indicated by the dotted lines ae, fb .

In Fig. 2, from the point a , which is the intersection of the upper line of the fillet with the vertical construction line, and with a radius equal to the width of the cove, describe a quarter circle intersecting the vertical and horizontal lines limiting the member. This concave outline is the profile of the molding technically termed the *cavetto*, though often called a *cove*.

In Fig. 3, locate the points a and c at the intersection of

the vertical construction line and the horizontal lines limiting the curved member. From a and c , by means of a 45° triangle, draw the diagonal lines ab and cd ; these lines will intersect at e , and will be the point of the reverse of curvature. Through e draw the horizontal line fg . From the point f , with a radius equal to fc , draw the arc che ; and from g , which is located on the vertical line bd , with the same radius, describe the arc eid ; then draw the vertical fillet lines from cd , completing the outline of the figure.

In Fig. 4, draw the vertical line ab , limiting the projection of the echinus $\frac{1}{8}$ inch from the vertical construction line. Draw the vertical line cd , at a distance of $1\frac{3}{8}$ inches from ab . Draw the tangent bc , by means of the protractor, at an inclination of $28^\circ 30'$ from the horizontal line. From the point f , which is $\frac{1}{4}$ inch below the lower edge of the upper fillet, draw the line fg parallel to bc . From g lay off gh equal to ge . Divide the line fg into five equal parts, and mark the points of division, as 1, 2, 3, etc., on fg . Divide fb into five equal parts, and mark the points of division, as 1, 2, 3, etc. on fb . From e draw a series of lines to the points of division on fb , and from h draw a series of lines through the points of division on fg . The intersection of the lines $c1$, $c2$, $c3$, etc. with the prolongation of the lines $h1$, $h2$, $h3$, etc. will give points through which the lower portion of the curve may be drawn from e to f , either freehand or with an irregular curve.

The convexity of the echinus will depend on the inclination of the tangent bc , for, as the angle is increased, the curve will be flattened. The upper portion of the curve from f to k is drawn freehand, after locating k $\frac{1}{8}$ inch to the right at ab . The ends of the fillets are then finished as above.

In Fig. 5, draw the vertical line ab $\frac{3}{16}$ inch to the right of the vertical construction line limiting the projection of the moldings, and from the point b , at the intersection of this line and the horizontal line bc , draw the diagonal line bd at an angle of 45° . From the point d , with a radius dc , describe

an arc, which will be the convex outline of the molding. then draw the ends of the fillets.

In Fig. 6, draw ab as above described, and from the point b , at the intersection of the vertical and horizontal lines ab and bc , draw a diagonal line at an angle of 45° . From a draw a similar line intersecting with the lower line of the molding at c . The line ac will intersect with the line ab in e . Through e draw the line fg , at right angles to bc . From the point f , with a radius equal to fe , describe the arc ea , and from the point g , with the same radius, describe the arc ec , thus obtaining the contour of the reversed curve, or ogee; then draw the ends of the fillets.

In Fig. 7, draw the line ab at a distance of $1\frac{3}{8}$ inches from, and parallel to, the vertical line limiting the projection of the lower fillet. Join c and d ; bisect cd at e . From c , with a radius equal to ec , describe the arc efd . From d draw the line dg , at an inclination of 30° from the horizontal. On dg as a base, erect an equilateral triangle $d hg$; from the vertex h , with a radius equal to hg , describe the arc $d ig$, which will be the lower curvature of the scotia. From the point b , at the intersection of the vertical line ab with the line hg , and with a radius equal to bc , describe the arc ejg , which will be the curve of the upper portion of the molding.

In Fig. 8 is shown a cyma recta, similar to that in Fig. 3, except that its lines are carried up in a slanting direction, as would be the case if it were applied to the gable, or pediment, of a building. At A , B , and C are shown three profiles of the molding, which are necessary to properly miter the pieces together at the angles formed at the eaves and return.

Draw the normal molding bjc by the method given for Fig. 3, but carry the lines of the upper fillet up from a and b at an angle of 30° . The lower fillet is then drawn horizontally and split at the end, to make it also extend diagonally and parallel to the upper fillet $a l''$. To find the contour of the molding which may be applied to the rake of the gable, or pediment, and to make it miter properly with bjc , divide the normal contour into six equal parts at fhj , etc., and from these points of division erect perpendicular lines until they

intersect with the horizontal line $l k$ drawn 1 inch above a . Also draw lines from f, h, j parallel to the raking lines of the pediment, as $f g, h i$, etc. Now, from k' , $1\frac{5}{8}$ inches from a , lay off $k' l'$ equal to $k l$, and divide $k' l'$ into the same number and sized parts as $k l$. This may be done by marking these divisions on a strip of paper and transferring them to $k' l'$. From these points of division, draw perpendiculars to $k' l'$, and, where these perpendiculars intersect the lines drawn from f, h, j , etc. parallel to the rake of the molding, points are determined through which the profile $l' c'$ may be drawn.

The return profile, which occurs near the top of an open pediment, may be found in a similar manner, as shown at C . Here $k'' l''$ is laid off horizontally and divided in exactly the same proportion as $k l$, and from these points of division perpendiculars are let fall to intersect with $f g, h i$, etc. as before, thereby locating points through which the molding may be contoured from l'' to c'' .

Having drawn all the figures in pencil, the student is now ready to ink in. As before stated, he should ink in each figure separately and finish it before commencing to ink the next figure, and it is well to ink them in the same order they were drawn in pencil. In inking in each figure, all the curves of that figure should be inked first, then the horizontal lines, then the perpendicular lines, and then the oblique lines. When the figures have been inked, the drawing should be cleaned, and after this the dimensions and dimension lines and the scale of each figure should be put in; also, if any part of the figure is shown in section, as will be the case with future plates, the part sectioned should be put in last. By putting in the sectional lines last, the likelihood of running them through the dimensions is greatly lessened. After this the border line should be inked in, and then the title, name of the student, his class number, and the date when he finished the drawing.

4. Sectional views of objects are represented in two ways: *first*, by coloring, and, *second*, by means of section

lines. When they are colored, different tints are used to represent different materials, so that, when a surface is to be tinted in which two or more different materials appear, one may be distinguished from another by its color. No general rule is strictly adhered to among architects by which certain tints will always represent certain materials. Each draftsman uses the color that suits his fancy. The general tendency, however, among all is to make brickwork of a reddish tint, stonework of a grayish tint, and woodwork of a yellowish tint, and so on, generally using a tint of about the color of the object. In this course of drawing none of the plates will be tinted, but sectional lines will be used exclusively. The same difficulty presents itself here as in the case with the tinting, that no standard is observed among architects, but each uses that style which he thinks best. It is impossible to have a separate style of section for each material, and therefore one style of sectioning may represent half a dozen different materials. The section lines ordinarily used will appear on the various plates to be drawn from this subject, and will be explained as they occur.

5. The alphabet shown in Fig. 3 below is the antique Egyptian style of letter, and is to be used for titles and headings. The letters and figures are to be made $\frac{5}{16}$ inch high and $\frac{5}{32}$ inch wide, exclusive of tips at top and bottom,

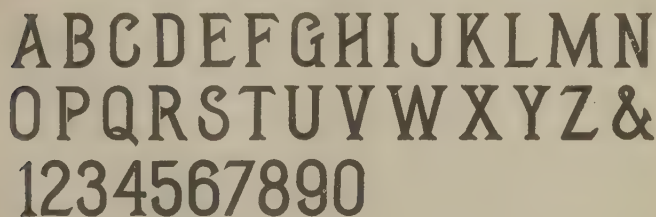


FIG. 3

except *M*, which is $\frac{1}{4}$ inch wide, and *W*, which is $\frac{5}{16}$ inch wide. The thickness of the lines forming the letters is $\frac{1}{32}$ inch. The distance between any two letters of a word is $\frac{1}{16}$ inch between the tips, except where *A* follows *P* or *F*;

where *V*, *W*, or *Y* follows *L*; where *J* follows *F*, *P*, *T*, *V*, or *W*; where *T* and *A* are adjacent, or where *A* and *V*, *W*, or *Y* are adjacent; in these cases, the lower extremity of *A* and the upper extremity of *P*, *T*, *V*, or *W* are in the same vertical line.

Since these letters are composed almost entirely of straight lines, they can be made with the **T** square and triangle, the corners being rounded freehand. The width of the letters *L* and *E* should be a trifle less than $\frac{5}{8}$ inch, say about $\frac{1}{8}$ inch, in order to equalize the appearance of the spacing. The tops and bottoms of the rounded letters should be drawn with a radius equal to $\frac{1}{2}$ the width of the letter, and should each extend a trifle above the line governing the general height, or they will appear too short. Horizontal spaces between the rounded letters should, for similar reasons, be a trifle less than between the straight letters. In making the title of the drawing plates, the student should draw six horizontal lines in lead pencil to represent the thickness of the letters at the top, center, and bottom; then, with the triangle, he should draw in the width of the letters and the spaces between them in pencil. Having the letters all laid out, he can very easily ink them in. When inking them in, it is well to ink in all the perpendicular lines first, next the horizontal lines, then the oblique lines, and the tips, the latter being drawn with a 45° triangle.

DRAWING PLATE, TITLE: DESCRIPTION OF ARCHES

6. The printed plate entitled, Description of Arches was obtained by making the drawing to the scale $\frac{3}{8}$ inch = 1 foot, and then reducing it slightly by photolithography. Consequently, the divisions on the scale shown on the plate are not quite $\frac{3}{8}$ inch, but as the figures are reduced in the same proportion, their dimensions may be obtained by measuring with the reduced scale on the plate. Assume that it is desirable to obtain the span of the

DESCRIPTION

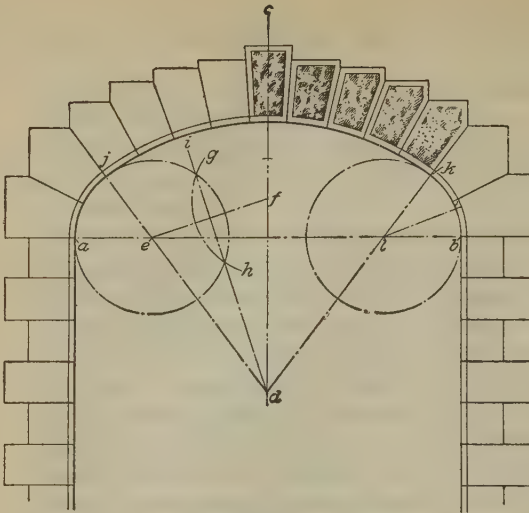


Fig. 1.

Scale

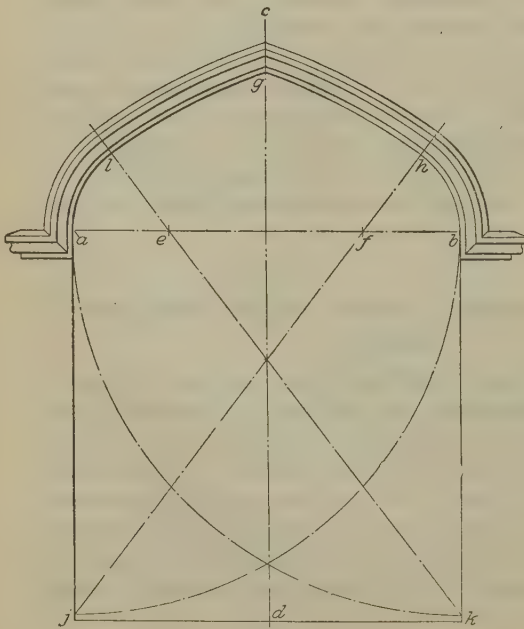


Fig. 4.

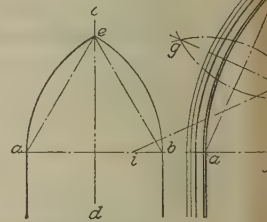


Fig. 5.

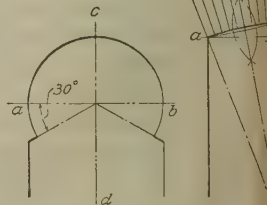


Fig. 8.

ARCHES.

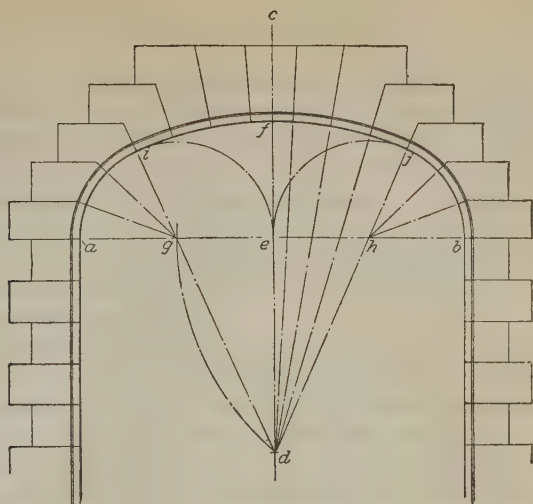


Fig. 3.

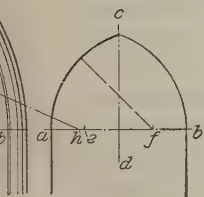


Fig. 7.

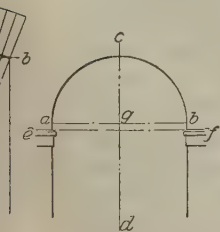


Fig. 10.

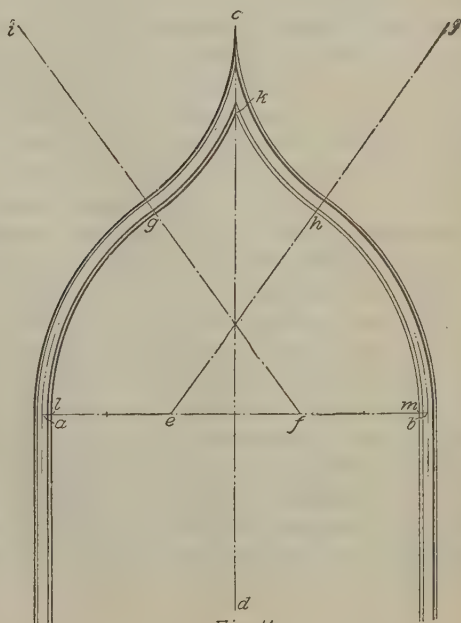


Fig. 11.

arch in Fig. 1. By setting the dividers to the points *a* and *b* and transferring them to the scale on the plate without changing their position, *ab* is found equal to 10 feet. Then, on the student's drawing, this distance just found is laid off to the scale $\frac{3}{8}$ inch = 1 foot, thus making *ab* equal to $3\frac{3}{4}$ inches. In the same manner the dimensions of any line may be found by setting the dividers to the distance on the printed plate and applying them to the scale, which shows the length in feet and inches.

The diagrams on the plate are given to demonstrate geometrical methods of laying out the several kinds of arches commonly used in building construction. Figs. 1 and 3 are known as *three-centered* arches, from the fact that their profiles correspond to the arcs of circles struck from three centers. Fig. 2 is commonly designated as a *flat* arch. This arch is built of wedge-shaped stones, which serve as a lintel. These stones are so formed as to produce a pleasing appearance, and form a treatment that is much used in some styles of architecture. Fig. 4 is commonly called a *four-centered Gothic* arch, sometimes known as a *Tudor* arch. Figs. 5, 6, and 7 are known specifically as *equilateral*, *lancet*, and *low*, respectively, while Fig. 11 represents an *ogee* arch. Figs. 8, 9, and 10 are formed from single arcs of a circle, and are designated as *Moorish*, or *horseshoe*, *segmental*, and *stilted semicircular* arches, respectively.

To proceed with the drawing of the plate, commence by laying out Fig. 1. Draw the center line *ab* $2\frac{2}{3}\frac{7}{8}$ inches from the upper border line, and the center line *cd* $3\frac{1}{16}$ inches from the left border line. Lay off the span and the rise to scale, which throughout the plate is $\frac{3}{8}$ inch = 1 foot. Divide the rise into three equal parts, and divide the span into five equal parts, thus locating the points *e* and *l*. Connect *e* and *f*, and, with *f* as a center and the same radius, describe the circles designated. With *f* as a center and the same radius, describe the arc *gh*, and through the points where it intersects the circle, draw the line *di*. Where this line intersects the vertical center line *cd*, will be the center for the arc of the circle forming the crown of the arch. This arc will continue from

the point j on the left to the point k on the right, at which points it will be tangent to the circles previously drawn. Draw the radial lines representing the joints between the voussoirs to the centers as designated, and finish the figure by drawing in the stones as shown. The term *voussoir* is French, and is given to the wedge-shaped stones that form the arch.

Commence Fig. 2 by drawing the vertical center line $c d$ exactly through the center of the clear space between the border lines, or at a distance of $8\frac{1}{2}$ inches from either of the side border lines. The line $a b$ is located $2\frac{7}{8}$ inches from the top border line. Draw the outline of the window opening $a b f g$ to scale, and with b as a center, and a radius $a b$, describe the arc $a e$. Where it intersects the center line $c d$, locate the point e , and draw $e a$ and $e b$. Divide $a b$ into seven equal parts, and from the point e , through these points of division, draw radial lines representing the lines between the voussoirs. Finish the outline of the voussoirs to scale, completing the drawing as shown.

Fig. 3 is another method for laying out a three-centered arch, and may be proceeded with by drawing the line $a b$ $2\frac{2}{3}\frac{7}{2}$ inches from the top border line, and a vertical center line $c d$ $3\frac{3}{16}$ inches from the right-hand border line. Locate the points a and b to scale and at a distance apart equal to the span of the arch, likewise the rise of the arch $c f$. Divide the span into four equal parts, and from the points g and h , with a radius equal to $a g$, describe semicircles as designated. From the point b , with a radius equal to $b g$, describe the arc as shown, and where it intersects the vertical center line locate the point d ; d will be the center from which to strike the arc $i f j$. The arcs $a i$ and $j b$ are portions of the semicircles previously described. Draw in the radial lines representing the joints between the voussoirs from their respective centers, and lay out the stonework to scale, as shown.

In drawing Fig. 4, locate the springing line $a b$ of the arch $4\frac{7}{16}$ inches above the lower border line, and the vertical center line of the arch $c d$ $3\frac{3}{16}$ inches from the left-hand border

line; locate a and b by marking off the width of the opening to scale, and divide the span of the arch ab into four equal parts, thus locating the points e and f . With b as a center and a radius equal to ab , and with a as a center and with the same radius, describe the arcs as shown. Where they intersect the sides of the opening, will be located the points j and k . From j , with a radius equal to jh , describe the arc gh , and from k , with a radius equal to kl , describe the arc gl . From e and f , with a radius equal to el , describe the arcs al and bh . Complete the outline of the opening, and draw in the architrave mold to scale as shown.

In Fig. 5, the line ab is located $4\frac{7}{16}$ inches above the lower border line, and the vertical center line cd , $6\frac{1}{8}$ inches from the left-hand border line. Lay off the span ab to scale, and with b as a center, and a radius equal to ab , describe the arc ae ; likewise from a describe the arc be .

The line ab in Fig. 6 is also located $4\frac{7}{16}$ inches above the lower border line. Lay off in this figure the span ab to scale, and locate the point e at a distance of ef from the line ab on the vertical center line cd , which is located in the center of the sheet. Lay off this distance to scale, which, in this arch, is always greater than the span. Connect a and e , and bisect the line ae by the method described in Art. 28, *Geometrical Drawing*, thus obtaining the line gh as designated. The point h will be the center from which to strike the arc ae , and i will be the corresponding center to the left of the vertical center line cd , from which to strike the arc be . Draw in the architrave mold as shown in the figure.

In Fig. 7, the springing line ab is located the same distance above the bottom border line as the same lines in Figs. 5 and 6, and the vertical center line cd is $6\frac{1}{8}$ inches from the right-hand border line. Having located to scale the points a and b at a distance apart equal to the span of the arch, divide the span ab into four equal parts, locating the centers e and f . From f , with a radius equal to fa , describe the arc ac . From e , with the same radius, describe the arc cb , thus completing this figure.

Fig. 8 requires no special description. The line ab is located $2\frac{1}{32}$ inches from the lower border line, while the vertical center line cd is a portion of the center line in Fig. 5, extended. Draw the figure to scale as shown.

The segmental arch, Fig. 9, is laid out by drawing the springing line ab $2\frac{21}{32}$ inches from the bottom border line. The center line cd is a continuation of the same line in Fig. 6. Lay off to scale the span ab and the rise ef , and connect a and f . Bisect the line af , and where the line hg intersects the vertical center line, as at g , will be the center from which to describe the arc afb . Divide the arc afb into twenty equal parts, and draw in the lines of the voussoirs that radiate from the point g and extend through the divisions just laid out.

Fig. 10 is simply a semicircular arch, designated as stilted because the line ab , upon which is located the center of the semicircle forming the arch, is some distance above the impost line ef . The line ab in this figure is a continuation of the line ab in Fig. 8, while the vertical center line cd is an extension of the same line in Fig. 7. Lay off the span and locate the center g , describing the semicircle acb . Working to scale, finish the figure as shown.

The springing line ab in Fig. 11 is $2\frac{11}{16}$ inches above the bottom border line, while its vertical center line cd is $3\frac{3}{16}$ inches from the right-hand border line. Lay off the distance ab to the center line of the bead and divide it into six equal parts; also mark off the several divisions of the mold to scale; e and f will be the centers from which to strike the arcs lg and mh . The arcs gk and hk are struck from the centers i and j , which can be obtained in this particular case by scaling the distance ig and hj . These arcs are arbitrary; that is, they can be made to suit the taste of the designer. Draw in the mold as shown.

Having completed the plate in pencil, block out the title and proceed to ink in, giving the same values to the lines as are given on the plate. All reference letters may be omitted.

FULL SIZE DETAILS

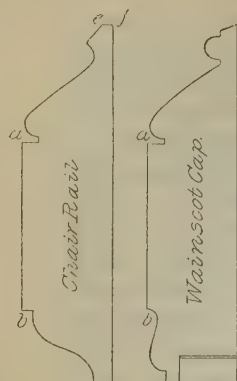


Fig. 1.

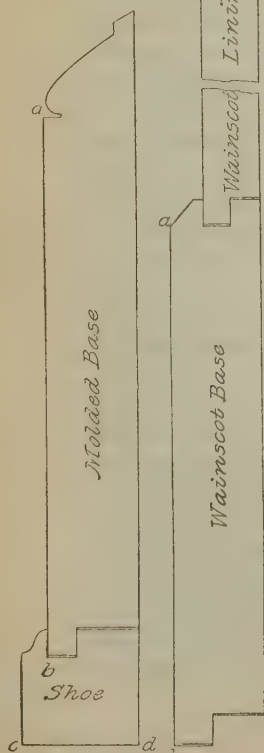


Fig. 2.

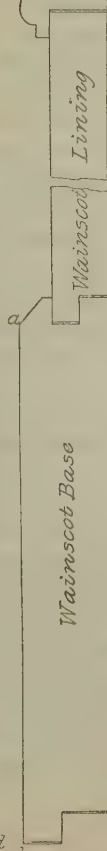


Fig. 3.

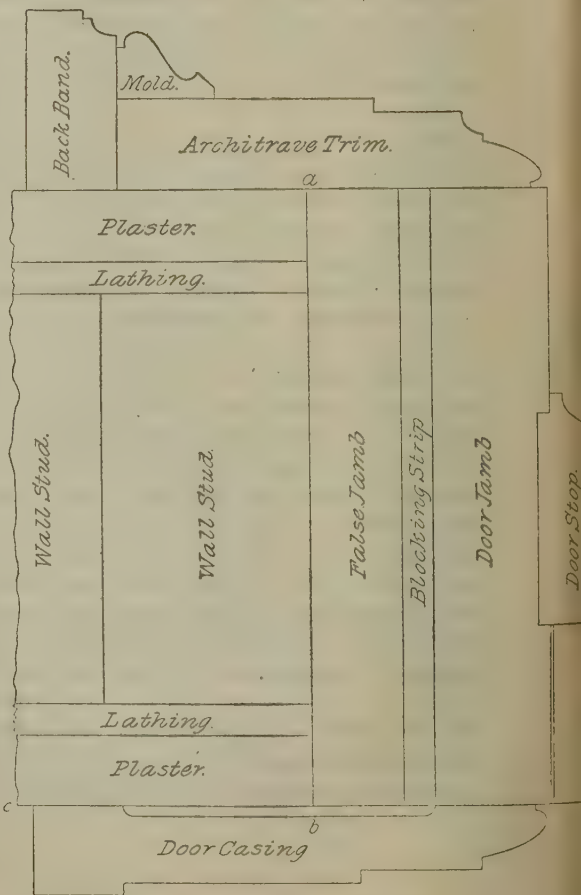


Fig. 7.



DRAWING PLATE, TITLE: FULL-SIZE DETAILS

7. In the five figures upon this plate are shown the full-size details necessary to construct the interior trim of a well-constructed building. Since the details are laid out full size, the scale at the right-hand lower corner of the plate represents inches and parts of an inch, and in making the drawing, a 2-foot rule, or any scale having inch marks on it, may be used.

Fig. 2 shows a molded base provided with a shoe, and the chair rail, which would be used in connection with it, is shown in Fig. 1. The **molded base**, or, as it is sometimes called, the **baseboard**, or **skirting**, is the finish placed around the bottom of a wall or partition, and, resting on the floor, forms a protection for the plaster. The chair rail answers a similar purpose, being placed at such a distance above the floor as will prevent the back of a chair from striking the plaster and thus disfiguring it. The lines ab , Figs. 1 and 2, are laid out $\frac{1}{2}$ inch from the left-hand border line, while the base line cd of the shoe is $\frac{7}{16}$ inch from the bottom border line, and the top line ef of the chair rail is marked off $1\frac{1}{4}$ inches from the top border line. Having thus located Figs. 1 and 2, they may be drawn to scale, great care being exercised in order to obtain the correct profile of the moldings, as a slight deviation may cause them to lose character and consequently beauty.

Fig. 3 shows a complete wainscot excepting the shoe. The wainscot base takes the place of the molded base shown in Fig. 2, and the wainscot cap answers the same purpose as the chair rail designated in Fig. 1. The wainscot lining protects the plaster between the base and the cap, and forms a pleasing finish for the room. The lines marked ab in this figure are located $1\frac{3}{4}$ inches from the left-hand border line. The figure may now be laid out to scale and finished, as shown.

Fig. 4 is the sectional plan through a portion of a door and its jamb. The several parts are clearly marked, and need no explanation. The line ab in this figure is located

$5\frac{13}{16}$ inches from the left-hand border line, while the line cd is situated at a distance of $1\frac{5}{16}$ inches from the bottom border line. It will be noted in this figure that a different method of construction is shown on either side of the door, the same remark applying to the jamb. The architrave trim, shown in the upper portion of the figure, is **only** used where there is a back band. Having thus located the principal lines in this figure, the several parts may be drawn to scale.

In order to finish the drawing plate, commence by laying off the line ab , Fig. 5, $6\frac{1}{4}$ inches from the right-hand border line, the line cd being $\frac{7}{16}$ inch from the top border line. This figure shows the usual method of constructing a window frame of an ordinary frame building or dwelling. The notes on the several parts make its construction sufficiently clear, and no further explanation is required, except that the student's attention is called to the fact that the wall stud in the window frame detail, Fig. 5, is made $4\frac{1}{4}$ inches instead of 4 inches, the usual size for studs of standard widths. Studs vary greatly in width, and the purpose of changing the width is to show the student that the window frames must be made to suit the actual width of the studs to which they are attached.

Ink in the plate with good, full lines that have the same value; no shaded lines are required on such a plate, since it is purely a working drawing.

DRAWING PLATE, TITLE: DETAILS

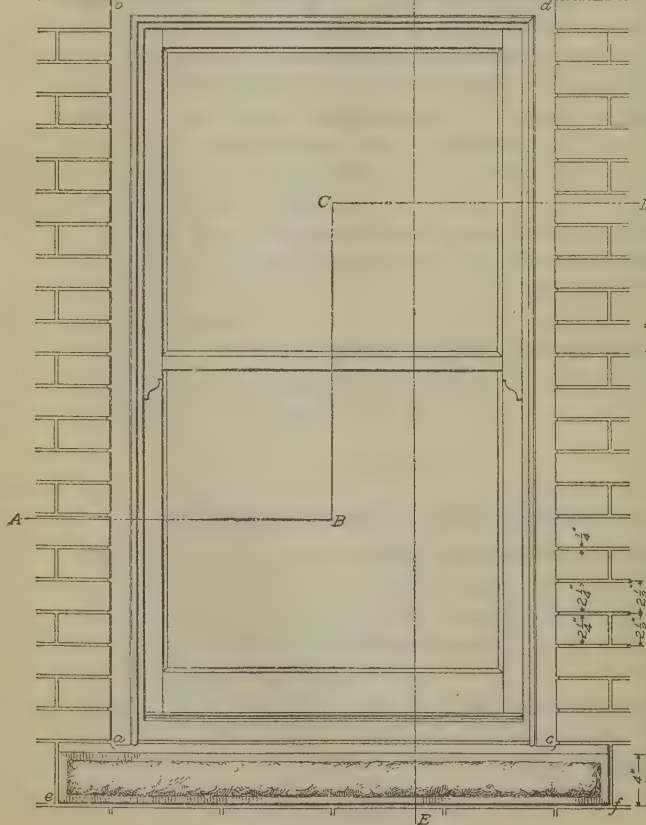
8. Fig. 1 of this plate shows an elevation, sectional plan, and vertical section of a **rear-veranda entrance door** for a frame house, and Fig. 2 shows the same views of a **window** of the ordinary double-hung sash type, for a brick wall with a straight stone lintel head.

Begin this plate with Fig. 1, drawing it to a scale of $1\frac{1}{2}$ inches = 1 foot. First draw the jamb lines ab and cd of the elevation 2 feet 7 inches apart, locating the line ab $2\frac{1}{8}$ inches

Technical drawing of a mechanical assembly, likely a pump or engine component, showing a cross-section with various dimensions and labels. The drawing includes a central shaft with a pulley or flywheel on the left and a piston or valve mechanism on the right. Dimensions are given in inches, with some values in feet and inches (e.g., 4'-1 1/2"). Labels include "Piston", "Flywheel", "Shaft", "Crank", "Connecting Rod", "Valve", "Pump", "Engine", "Machine", "Part", "Drawing", "No. 1", "2", "3", "4", "5", "6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19", "20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33", "34", "35", "36", "37", "38", "39", "40", "41", "42", "43", "44", "45", "46", "47", "48", "49", "50", "51", "52", "53", "54", "55", "56", "57", "58", "59", "60", "61", "62", "63", "64", "65", "66", "67", "68", "69", "70", "71", "72", "73", "74", "75", "76", "77", "78", "79", "80", "81", "82", "83", "84", "85", "86", "87", "88", "89", "90", "91", "92", "93", "94", "95", "96", "97", "98", "99", "100".

Arch. Br.

4' 4'



WINDOW FOR BRICK WALL,
Scale $1\frac{1}{2}'' = 1\text{ft.}$

Fig. 2.



from the right-hand border line. Then draw the sectional plan across the elevation of the door, as shown, completing it before starting to draw anything else. Do this by drawing the section of the door first, which is $1\frac{5}{8}$ inches thick, with panels $\frac{1}{2}$ inch thick, and complete it from the dimensions given, proportioning the moldings of the door by the eye. Observe that the panel moldings on the outside face of the door are raised and lap a little over the edges of the stiles, while the moldings on the other side of the panels are sunk below the inside face of the door. Having finished the section of the door, now draw the frame of the door, first drawing the jambs e, e , which are $1\frac{1}{2}$ inches thick and 6 inches wide, with a $\frac{1}{2}$ -inch rabbet; next, the outside casings f, f , which are $1\frac{1}{8}$ inches thick and 5 inches wide; and then draw the door studs, which are composed of two thicknesses of scantling 2 in. $\times$ 4 in., and complete this view from the dimensions given; this the student should be able to do without difficulty. Now start the vertical section (which is taken on the line GH) by first drawing the section of the door, the height of which is 6 feet 8 inches, and then drawing the remainder of the vertical section from the dimensions given. Locate the top edge of the door at a distance of $1\frac{7}{16}$ inches from the upper border line. Next draw the elevation of the door and frame. Do this by projecting all the perpendicular lines from the sectional plan and the horizontal lines from the vertical section, as these two sectional views give all the dimensions necessary. The student should experience no difficulty in completing this view.

Draw Fig. 2, the window for a brick wall, to a scale of $1\frac{1}{2}$ inches = 1 foot. Begin with the elevation of the window, by drawing the brick jambs $a b$ and $c d$ at a distance of 2 feet 10 inches apart, locating the jamb $a b$ $1\frac{1}{4}$ inches from the left-hand border line. Then draw the bottom bed $e f$ of the stone window sill at right angles to the jambs, and at a distance of $\frac{5}{8}$ inch from the lower border line. From the highest point of the stone window sill, which is $4\frac{3}{4}$ inches above the edge $e f$, as will be seen, lay off a distance of 4 feet $9\frac{3}{4}$ inches, and through it draw the lower side $g h$ of the

stone lintel, completing both the lintel and the stone window sill from the dimensions given. Now draw the sectional plan of the window and the wall. This plan shows a section taken on the broken line $A B C D$, the left-hand portion of the plan being a section through the lower sash and the wall, and the right-hand portion, a section through the upper sash and the wall. Draw the brick wall first, which is $12\frac{1}{2}$ inches thick, as shown; then draw the window frame and the sashes from the dimensions given, drawing the frame first. Draw the lines of the sashes to the center line ij and stop them there. This is the general practice, as the sides of the sash and frame are alike, and half of the sash shows the construction of it as well as would the whole. Having finished this, draw the casing from the dimensions given. The two circles on each side of the window frame represent the sash weights. Now draw the vertical section of the window, which is a section taken on the line $E F$. Draw the brick wall first, projecting the lintel and the stone window sill from the elevation, and then the window frame and the sashes from the dimensions given, drawing the frame first. After this draw the casing from the dimensions given. All the small details of the construction should be plainly drawn and figured. Now complete the elevation, making use of the sectional plan and the vertical section, by projecting all horizontal lines from the vertical section and all perpendicular lines from the sectional plan. The brickwork is laid out in $2\frac{1}{2}$ -inch courses, that is, $2\frac{1}{2}$ inches from center to center of joint. Complete the figure from the dimensions given.

9. The style of the section lines ordinarily used to represent wood cut across the grain is as shown in Fig. 1 of this plate. This is done by a series of irregular rings and radiating lines like the cross-section of an oak tree, which are to be made freehand with an ordinary writing pen.

The style of section line used to indicate plaster is also shown on this plate, and consists of a number of dots made freehand with an ordinary writing pen. The glass panes

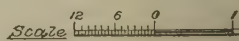
S



Fig. 1.



Fig. 2.



WINDOW.

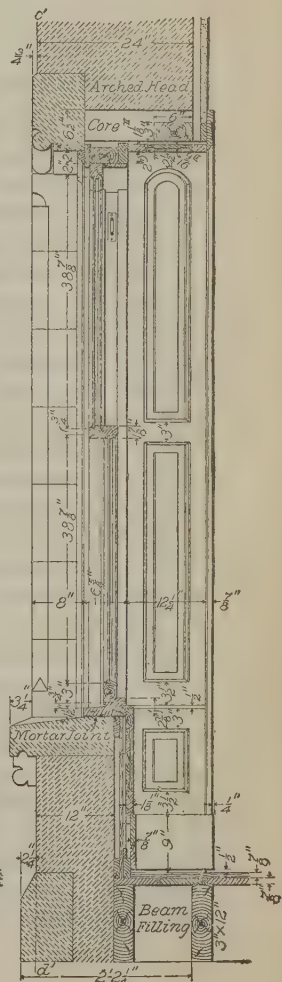
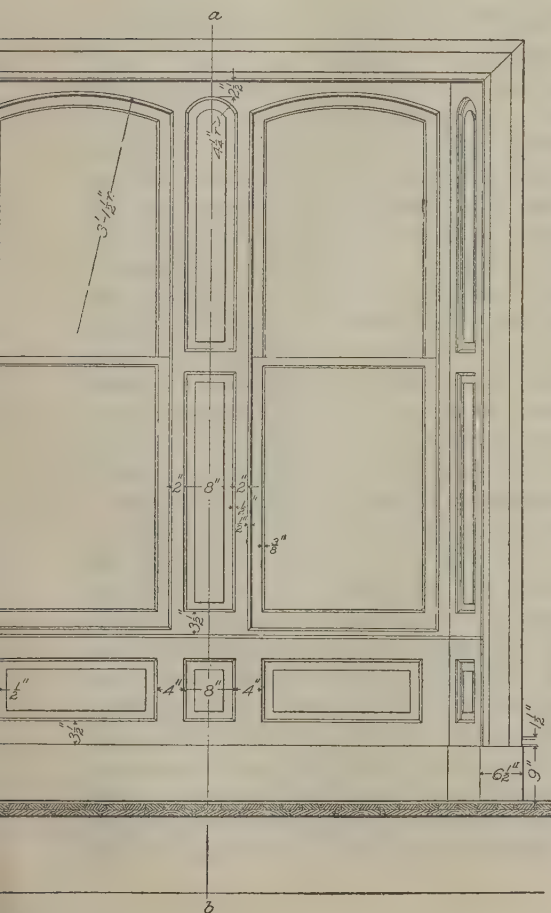
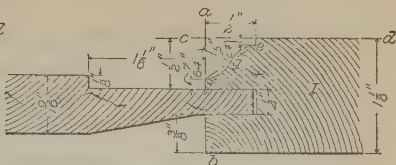
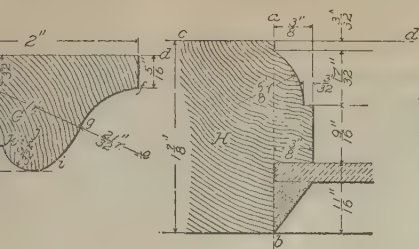


Fig. 3.

Fig. 4.

are sectioned similar to brickwork. When it is desired to make the drawing show up well, some of the surfaces are slightly shaded. This has been done with the stone sill and lintel of the elevation in Fig. 2. Here the stone is shaded, and clearly shows its surface treatment. The margins are shown to be clean cut, while the remainder is rock face.

DRAWING PLATE, TITLE: MULLION WINDOW

10. This plate represents the detail drawings for a **mullion window**, consisting of the plan, exterior elevation, interior elevation, and vertical section, all drawn to the scale of $\frac{3}{4}$ inch = 1 foot, together with several sections of the moldings drawn full size. The window is constructed in a stone wall, the exterior being finished with cut-stone trimmings, while the interior is constructed to have splayed jambs. The openings are fitted with a wooden-box frame and double-hung sliding sash, but inside blinds, or shutters, are dispensed with, and the jambs, soffit, and breast are finished with framed, molded, and paneled linings. The window heads are segmental in form on the exterior, while the interior soffit is finished so as to be horizontal. An arch spans the opening between the jambs, to which a scantling of timber is attached horizontally on the interior, to serve as a base for the furring strips and plaster grounds.

Begin Fig. 1, the *plan* (which is a horizontal section on the line $ABCD$ of Fig. 2), by drawing the center line ab at a distance of $4\frac{1}{16}$ inches from the left-hand border line; draw cd , the outer face line of wall, at a distance of 3 inches below the upper border line. Each half of the plan is symmetrical, and that portion to the left of the center line ab should be drawn first. Lay off, on the line cd , one-half the width of the *mullion*, or upright division between the openings; mark the width of the opening, and draw the reveal lines. Draw the face line of the trimmings, which is $\frac{3}{4}$ inch in advance of the line cd ; make the depth of the reveal 8 inches, and draw ef , the outer face line of the box frame;

then form the rebate in the jamb in which the frame is placed.

From the line cd mark the thickness of the wall, which is 24 inches, and a space of $2\frac{1}{8}$ inches additional for furring and for lath and plaster, as shown; then draw the horizontal lines, representing the plaster, etc., after which draw the splay of the jambs so that the inside of the opening is 4 inches wider on each side of the center line than the outside opening. From the line ef mark a series of points defining the members composing the thickness of the window frame, $\frac{7}{8}$ inch for the outer casing, $1\frac{7}{8}$ inches for the upper sash, $\frac{1}{2}$ inch for the parting strip, $1\frac{7}{8}$ inches for the lower sash, and $1\frac{1}{2}$ inches for the width of the sash top; make the inner casing $1\frac{1}{8}$ inches thick, and through the points marked draw the horizontal lines defining the details as laid out. Draw the face line of the pulley stiles, which is 2 inches in advance of the stone reveal; mark $1\frac{1}{8}$ inches for the thickness of each pulley stile, $2\frac{1}{2}$ inches for the depth of the weight box, between the pulley stiles and back lining, and $\frac{7}{8}$ inch for the thickness of the back lining; then draw the lines defining these details. Form the groove in each pulley stile $\frac{3}{8}$ inch deep for the parting strip, and form the tongues on the pulley stiles which enter the inner and outer casings. Observe that the sash stop, parting strip, and edge of the outer casing are all in line. Make the width of the sash stiles 2 inches to the glass line, but add an extra $\frac{3}{8}$ inch for rebate. (Fig. *H* shows a full-sized detail of this edge of the sash.)

Locate the vertical plaster ground at the inside edge of the splayed jambs, formed with a rebate to receive the lath and plaster, and draw the paneled jamb lining in position, a full-sized detail of which is shown in Fig. 1. Draw the inside trim, or casing, lapping over on the edge of the jamb lining and entirely covering the plaster ground; draw the line of the window breast $1\frac{1}{8}$ inches inside of the frame and the line of the base, and the baseboard $\frac{3}{16}$ inch in advance of the paneling and casing. Draw the panel in the inside casing of the mullion, the sash weights in the box, the exterior

molding in the angle between the window box and the stone reveal, and then the line defining the front edge of the stone sill; draw the miter lines denoting the intersections of the sloping surfaces of the sill, and the chamfers formed by the cutting off of the corners of the quoins at the side of the mullion in the center. Having drawn the left half of the plan, draw the right half and complete the figure, observing that on the right-hand side the section through the elevation (Fig. 2) is taken through the upper sash, and therefore shows the sash on the right side of Fig. 1, in the exterior sash groove of the frame.

Begin Fig. 2, the **exterior elevation**, by drawing ef , the top line of the sill, at a distance of $3\frac{1}{8}$ inches above the lower border line, and draw gh , the springing line of the segment heads, at a distance of 7 feet above the line ef ; project the reveal lines from Fig. 1, and from the points i and j , with a radius of 3 feet $3\frac{1}{2}$ inches, describe arcs whose intersection at the point k will locate the center from which the segmental curve may be drawn. Beginning at lm , the lower line of the base course, mark a series of points defining the heights of the base course, the sill blocks, and sill, the height of each quoin, and the lintel, and through the points so marked draw horizontal lines; make the width of the headers, or narrow stones, 10 inches, and the length of the stretchers, or wide stones, 16 inches; draw the vertical lines defining these stone details, and draw the chamfers on the angles of the jambs and mullions, with their top and bottom stops.

Before drawing the frames and sash in the elevation, it will be necessary to draw Fig. 4, which is a **vertical section** on the line EF of Fig. 2. Draw $c'd'$, the vertical face line of the wall, at a distance of $2\frac{7}{16}$ inches from the right-hand border line; draw the face line of the quoins $\frac{3}{4}$ inch in advance of the line $c'd'$; lay off the thickness of the wall and the space for furring, and lath, and plaster, as in Fig. 1, and the thickness of the breast in the masonry under the sill, which is 12 inches, and draw the vertical lines. Project, from Fig. 2, the horizontal lines that mark

the stone courses and window opening, and transfer the lines defining the depth of the reveal, and the division of the box frame, by means of a strip of paper applied on the line EF of Fig. 1, which the lines of these details intersect. The various points should be carefully marked with a needle point on the paper strips, and then punctured in their positions on Fig. 4, after which the vertical lines can be drawn through them. Locate and draw the wooden sill of the frame, and the lower rail at the bottom, the meeting rails at the center, and the upper rail at the top of the sash, in accordance with the measurements given. Draw the $3'' \times 6''$ scantling under the arched head, which forms the support for the furring and plaster grounds; draw the floor joists and the double floor in position, as shown (the lower floor is laid over the joists diagonally, while the upper, or finished, floor is placed at right angles to the joists), and draw the furring and sheathing behind the stone breast of the window; draw the section of the paneled breast, and observe that the base is kept up $\frac{1}{2}$ inch above the finished floor, to allow the carpet to pass under it.

In order to draw the paneling, etc. of the jamb on Fig. 4, it will be necessary to project the lines of the jamb finish on Fig. 1 forward to EF , the line of section on which Fig. 4 is taken; this can be done by drawing from each detail of the panel jamb a horizontal line with the T square, and after marking the points so located, as shown at 1, 2, and 3, transfer their relative positions by means of a strip of paper, as explained in connection with the reveal and window box. The vertical lines and the lines of the horizontal framing, etc. may then be located and drawn. Having now completed Fig. 4, return to Fig. 2, and draw the frames and sash in the window openings, projecting the vertical lines from Fig. 1, and the horizontal lines from Fig. 4, and describe the curves of the segment heads of the sashes from the same centers as were used for the stonework.

Begin Fig. 3, the **interior elevation** of the window, by drawing the center line ab at a distance of $6\frac{1}{16}$ inches from the right-hand border line; project the horizontal divisions

of the sash and inside finish from their respective positions in Fig. 4. In order to locate the vertical divisions, first draw the line lm in Fig. 1, at any position in advance of the wall line, and intersect lm by a series of perpendicular lines from the members of the frame, sash, and finish, marking their position on lm as shown; then transfer these points and their distance from the line ab by means of a paper strip to the inside elevation of Fig. 3; make the line ab on the paper strip coincide with the center line ab in Fig. 3, and prick the points with a needle, thus marking the divisions on one half of the elevation. The points on the other half can then be marked by reversing the strip, noting carefully that the line ab on the strip again coincides with the center line ab of Fig. 3. Now draw the vertical lines through the points as marked, and complete the figure by drawing the curved heads of the frame, sash, and finish, as shown.

Begin Fig. *G*, a full-sized section of the **exterior angle** molding of the frame, by drawing the line ab at a distance of $8\frac{3}{4}$ inches from the right-hand border line, and the line cd at a distance of $1\frac{7}{16}$ inches below the upper border line; draw the lines defining the width and thickness; then from the center e , with the radius given, draw the arc fg ; join eh ; from h as a center, with a radius equal to hg , draw the arc gi , of the length given; locate the center j and draw the arc ik ; draw the quirk, or channel, between the molding and the fillet, and complete the figure. The center e may be located by striking an arc from f as a center, and with a radius of $2\frac{1}{8}\frac{1}{2}$ inch, and intersecting this arc by another drawn from h as a center and with a radius of $1\frac{2}{8}\frac{1}{2}$ inches. The center j may then be located, so that the arc struck from it will be tangent to the arc gi and also to the bottom line of the molding.

Begin Fig. *H*, a full-sized section of the **edge of the sash**, by drawing the line ab $5\frac{1}{2}$ inches from the right-hand border line, and the line cd $1\frac{5}{16}$ inches below the upper border line; mark the thickness of the sash $1\frac{7}{8}$ inches; divide it into the members shown, and draw the horizontal and vertical lines. Draw the rebate for the glass and putty fillet on the

outside, and draw the molding on the inner edge, with a circular arc, as shown.

Begin Fig. 1, a full-sized section of a portion of the **framed paneling** of the linings, by drawing the line ab at a distance of $2\frac{1}{8}$ inches from the right-hand border line, and the line cd at a distance of $1\frac{5}{16}$ inches below the upper border line; draw the lines for the thickness of the framing, and form the groove for the panel. To draw the ogee molding, first locate the points e and f and join them with a line ef ; bisect this line at g , and from e and g as centers, and with a radius equal to eg , describe intersecting arcs, from the point of intersection of which describe the arc eg with the same radius. The arc gf may then be drawn by the same process. The panel, which is $\frac{9}{16}$ inch thick, has a margin sunk $\frac{1}{8}$ inch on its edges on one side, while on the opposite side the edge is beveled off to $\frac{1}{4}$ inch in thickness where it enters the groove in the stile; observe that the panel does not fill the full depth of the groove, this extra allowance of groove permitting the panel to swell without affecting the joints of the framing.

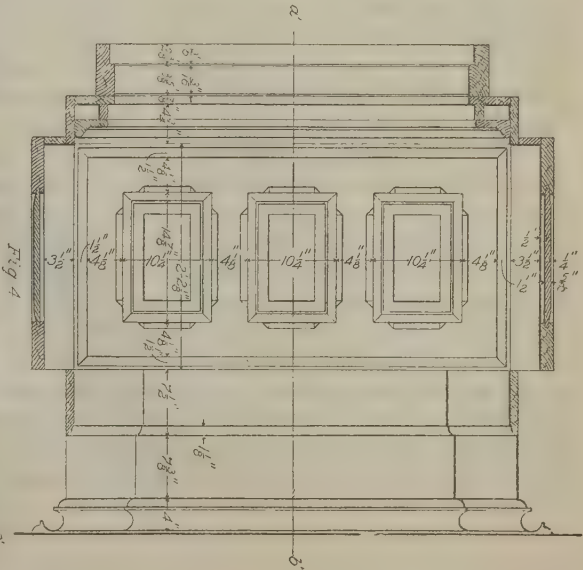
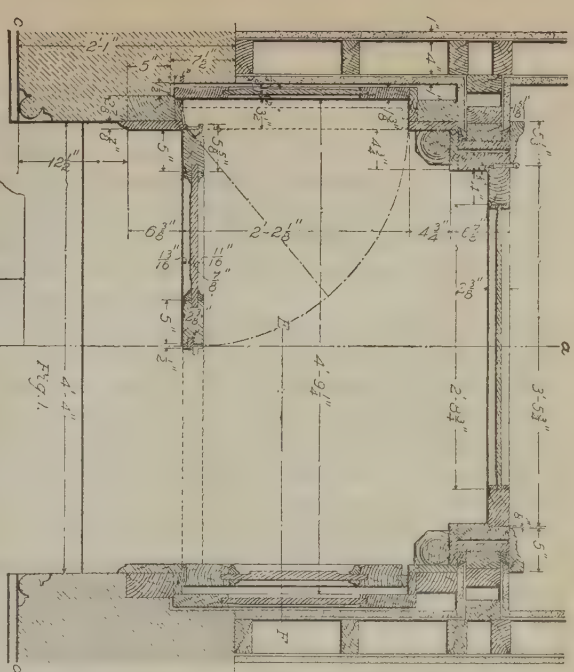
DRAWING PLATE, TITLE: DETAILS OF VESTIBULE

11. This plate represents the detail drawings for a vestibule, consisting of the floor and ceiling plans, the exterior and interior elevations, and a vertical section, all drawn to a scale of 1 inch = 1 foot.

The entrance doorway is constructed in a stone or brick wall, the exterior having cut-stone trimmings, finished with an angle mold. The entrance, or exterior, door is made in two leaves with rebated central joint, each leaf being hung flush with the jamb stop, and arranged to fold into a pocket, thus utilizing the full width of the vestibule. The pockets are finished with paneled linings, and the ceiling is finished with paneling to match the doors. The vestibule, or interior, door is made in one leaf, and fitted to rebated jambs, and the framing of the door is less in width at the glass panel than

DETAILS OF VESTIBULE.

Scale 1" = 1 ft.



below. The exterior trim of the vestibule door is ornamented with a circular shaft and carved capital, which supports a molding; across the top, and part way down each side, the doors and paneled work are assumed to be veneered, and are therefore considerably thicker than would be the case if they consisted of but a single thickness of wood. The upper panels of both the entrance doors and the vestibule door are beveled plate glass.

After drawing the border line, commence Fig. 1, the **plan** (which is a horizontal section on the line AB of Fig. 2), locating the center line ab at a distance of $3\frac{3}{4}$ inches from the left-hand border line, and cd , the outer face line of the wall, at a distance of $6\frac{1}{4}$ inches below the upper border line.

Each half of the plan is symmetrical, and that portion to the left of center line ab may be drawn first. As the full opening in the masonry is 4 feet 4 inches wide, lay off one-half of this measurement to the left of the center line ab , and draw the reveal line and the angle molding, as shown; then, from the line cd , mark a series of points on the line ab defining the divisions of the reveal of the jamb in the masonry, $12\frac{1}{2}$ inches for the stone reveal, 5 inches for the rebate to receive the door frame, and $7\frac{1}{2}$ inches for the rebate to receive the pocket lining back of the door, making the total thickness of the wall 2 feet 1 inch; draw the door frame in the rebate $2\frac{7}{8}$ in. $\times$ $5\frac{1}{2}$ in. in section. The door stop, which is $\frac{7}{8}$ inch thick, laps over on the stone and the inner casing, which is also $\frac{7}{8}$ inch thick, covering the edge of the frame; draw in the entrance door, which is $2\frac{3}{8}$ inches thick and passes $\frac{5}{8}$ inch behind the face of the door stop. Locate the center of the hinge pin, which is assumed to be $\frac{5}{8}$ inch in diameter, and describe a quarter circle indicating the swing of the door, as shown; draw the dotted outline of the door in its position when swung back in the pocket, and arrange the paneled lining behind same; locate and draw the vestibule door and frame, the section of the partition, casings, and trim by the measurements given; the door is $2\frac{3}{8}$ inches thick, and the frame is 2 inches thick; then draw the angle shaft adjacent to vestibule door. That portion of

the plan to the right of center line $a b$ may now be drawn and the figure completed.

Begin Fig. 2, the left half of which shows the **exterior elevation** of the entrance door, while the right half shows the **interior elevation** of the vestibule; draw ef , the floor line, at a distance of $\frac{3}{4}$ inch above the lower border line; project the reveal of the left-hand jamb from Fig. 1, by drawing the line parallel to center line $a b$; lay off the courses composing the stonework of the jamb; mark the height of the lintel, and draw the horizontal lines; locate the center, and describe the curve of the corbel under the lintel, and from the same center draw a vertical line defining the end of the corbel; project the vertical lines of the angle molding from Fig. 1, and continue the molding around the corbel and across the door head on the lintel, as shown; then mark a series of points on the center line $a b$, defining the horizontal members of the door framing, and draw the lines; mark the width of the framing and draw the vertical lines; lay off the width of the moldings, the chamfers on the edge of the framing, and the margins of the raised panels, and draw the lines.

The student will undoubtedly notice that there are more members in the top mold of the principal and bottom panels than in the bottom mold. The ogee mold shown in the section continues around the panel, in each case being mitered at the corners. The bottom member, however, is in each panel a simple chamfer so as to readily shed water, and since the necessity does not arise so much at the top of the panel the mold here consists of a bead or half-round member having a **quirk**, channel, or groove at its upper edge.

Before drawing the right-hand portion of the figure, proceed with Fig. 3, the **vertical section** of the vestibule, by drawing $c' d'$, the face line of wall, at a distance of $\frac{3}{4}$ inch from the right-hand border line; produce ef , the general floor line, from Fig. 2, and on it mark a series of points defining the vertical lines of the stone reveal and jamb stop, the paneled lining of the door pocket, the shaft and hood mold composing the exterior trim of the vestibule, the door

frame, interior trim, etc., and draw them; on the line $c'd'$ mark a series of points defining the horizontal divisions of the paneled lining, the shaft with its base, band, and capital, the head of the door frame, hood mold, ceiling paneling, angle molds, etc., and draw the lines; draw the angle mold at the ceiling and on the stone jamb by means of the bow-pencil, the carved capital of the shaft, the pedestal band, and the other moldings to be drawn freehand; draw the floor line of the vestibule, which has a pitch of $\frac{3}{8}$ inch from the saddle of the vestibule door, and also draw the line of the platform in front of the door step, and complete the figure.

Now draw the right-hand portion of Fig. 2, the interior elevation of the vestibule taken on the line EF of Fig. 1; project the horizontal lines from Fig. 3, and the vertical lines from Fig. 1; arrange the paneling in the framing as shown; project the horizontal lines of the door framing from the entrance door; mark the width of the vertical framing and the top rail, and draw the lines; draw the molded and carved work and complete the figure.

Begin Fig. 4, the **plan of the ceiling**, as seen from below, and taken on the line cd , of Fig. 2, by drawing the center line $a'b'$, at a distance of $3\frac{5}{8}$ inches from the upper border line; project the vertical lines from Fig. 3, and from the center line $a'b'$ lay off and draw the horizontal divisions of the paneling, the door frame, hood mold, door pockets, etc., and complete the figure.

DRAWING PLATE, TITLE: STEEL COLUMNS AND CONNECTIONS

12. In this plate are shown two designs of columns used in the construction of modern office buildings, and a common method of connecting the floorbeams to the columns is shown. A side view and a front view of each design is given, and as it would manifestly be impossible to draw the columns in their full length, and since, besides, it would not serve any useful purpose to do so, a part of the column between the base and the floorbeam connection is broken

away. When this is done, it is understood that the part broken away is similar to the ends of the column next to the break, which in this case is indicated by drawing a line consisting of a long dash and two dots across the column. Among mechanical draftsmen it is customary to indicate a break by a wavy freehand line, but many architectural draftsmen indicate a break in the manner shown in this plate. The student's attention is also called to the fact that the style of lettering used for the title and notes differs somewhat from the preceding plates. The construction of the letters in both the title and the notes is explained in *Geometrical Drawing*. The lettering on this plate is more consistent with the class of work shown, but the student may use the more ornamental type for the heading and the single line italics for the notes employed on the other plates, if he prefers.

In the design shown in Fig. 1 of the plate, and in perspective in Fig. 4 (a), the column consists of two 15-inch channels *a*, *a* placed back to back and tied together by cover-plates *b*, *b*, 12 inches wide. The column is supported on a steel bedplate $24'' \times 25'' \times \frac{5}{8}''$, to which it is attached by side plates *c*, *c* and angle irons *d*, *d* riveted securely to the bedplate. Each channel, for further security, is tied to the bedplate by an angle iron, as *e*. The column supports two pairs of longitudinal floorbeams *f*, *f*, *f*, *f* and two transverse floorbeams *g*, *g*. Each pair of longitudinal floorbeams is supported on a horizontal bracket made from a $5'' \times 5''$ angle iron *h*, and stiffened by two $4'' \times 3''$ angle irons *i*, *i* placed back to back. A filling piece *j* is placed between the cover-plate and the lower part of the angles *i*, *i*. The longitudinal floorbeams are tied on top to the column by a $5'' \times 5''$ angle iron *k*. Each transverse floorbeam rests on a bracket made from a $4'' \times 6''$ angle iron *l*, stiffened by a $3'' \times 2\frac{1}{2}''$ angle iron *m*, placed as shown. A $4'' \times 4''$ angle iron, as *n*, ties the top of these floorbeams to the column by means of two $\frac{3}{4}$ -inch bolts. The column is made in sections, the lower section being 22' 8" high. The upper section is spliced to the lower section by the vertical splice

Scale 1:

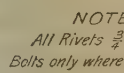


Fig. 1.

CONNECTIONS.

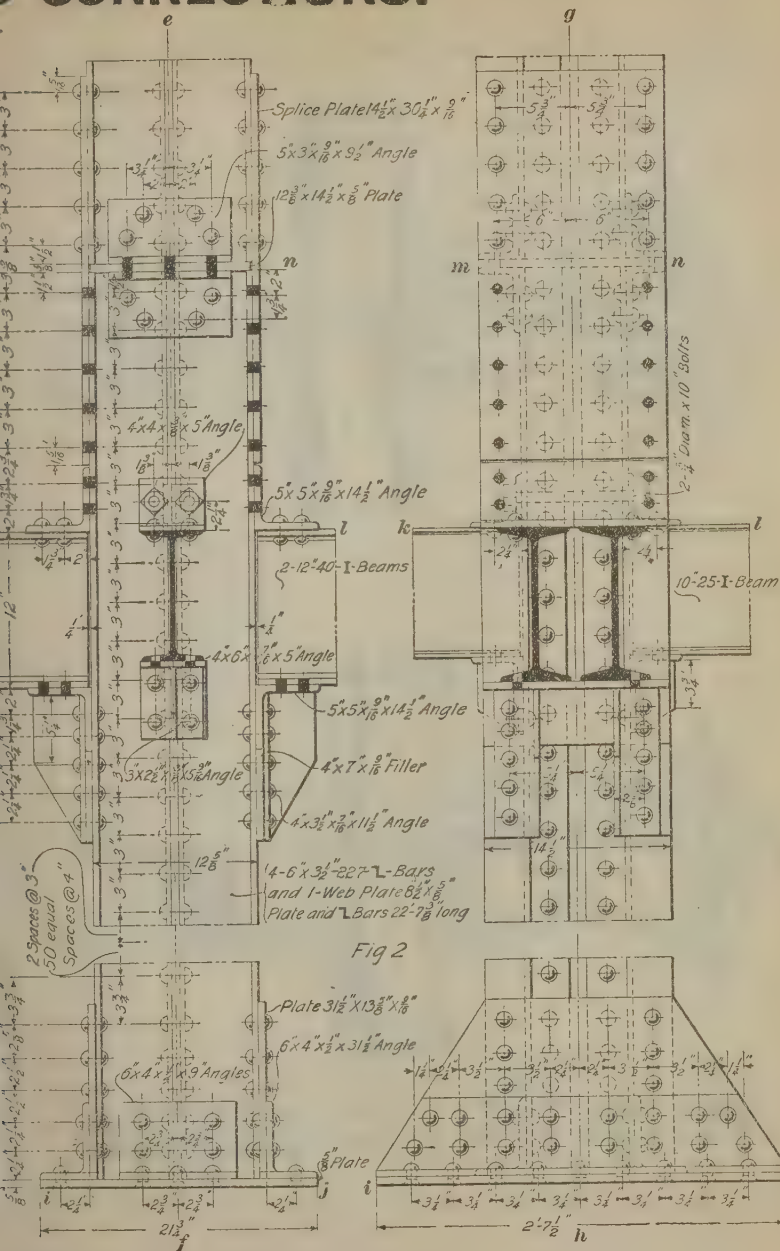
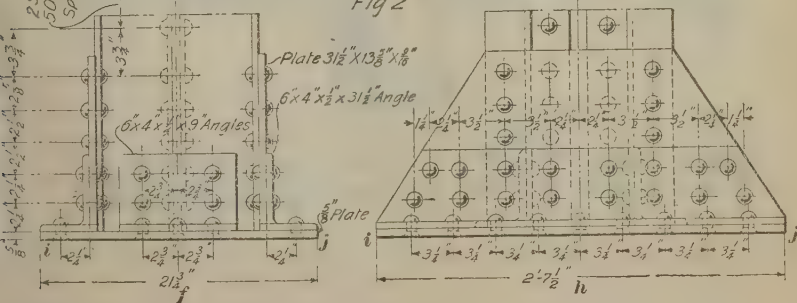


Fig 2



plates *o, o*, a horizontal splice plate *p*, and 5" $\times$ 3" angle irons *q, q*.

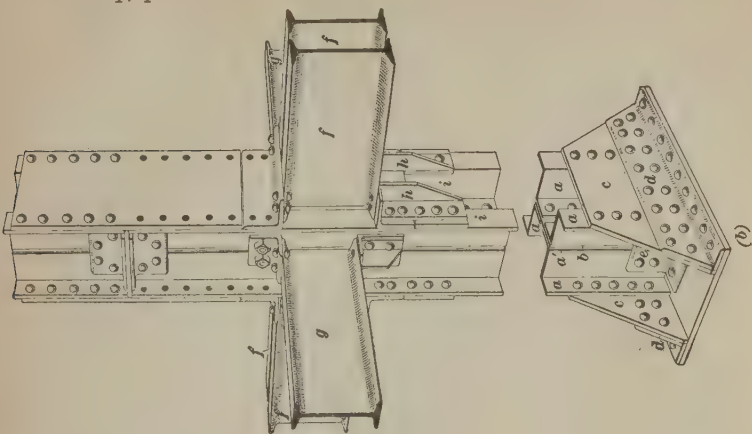
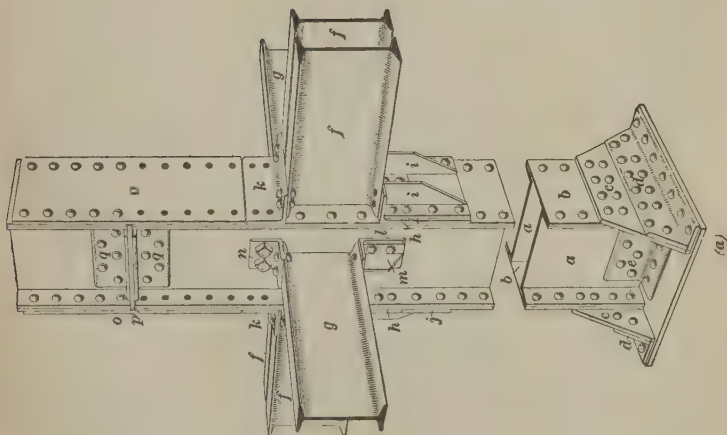


FIG. 4.



The column shown in Fig. 2 of the plate, and in perspective in Fig. 4 (*b*), is built up from four **Z** bars *a, a, a, a*

securely riveted to a web-plate *b*. Since the edge *a'* is the dark edge of a recess, it should be shaded, according to the rules of shading. On referring to Fig. 2 of the plate it will be found that the line corresponding to *a'*, Fig. 4 (*b*), is made a light line instead of a shade line, as it should be. This is a conventionalism adopted frequently by experienced draftsmen, who will omit a shade line when its presence will render the drawing, or part of it, indistinct instead of clearer. It is readily seen that if the line mentioned is shaded on Fig. 2 of the plate, it will not be possible to show correctly the thickness of the web of the **I** beam; hence the line is left light. The column, as shown in Fig. 4 (*b*), is supported on a steel bedplate $21\frac{3}{4}'' \times 31\frac{1}{2}'' \times \frac{5}{8}''$, to which it is attached by the side plates *c*, *c* and angle irons *d*, *d*. For further security each pair of **Z** bars is tied to the bedplate by an angle iron, as *e*. Two pairs of longitudinal floorbeams *f*, *f*, *f*, *f* and two transverse floorbeams *g*, *g* are connected to the column in practically the same manner as those shown in Fig. 4 (*a*). A slight difference in the construction of the brackets supporting the longitudinal floorbeams will be noticed. Instead of using a single filling piece under the two stiffeners *h*, *h*, a separate filling piece, as at *i*, *i*, is used under each stiffener. Each transverse floorbeam is supported on a bracket made from a $4'' \times 6''$ angle iron stiffened by a $3'' \times 2\frac{1}{2}''$ angle iron, and is tied on top by a $4'' \times 4''$ angle iron riveted to it and bolted to the column. This column, like the other column, is built in sections, the upper section being spliced to the lower section by two vertical splice plates, one horizontal splice plate, and angle irons. It will be noticed that the manner in which the splice is made is identical with that used to splice the sections of the column shown in Fig. 4 (*a*).

In the drawings there will be noticed several conventionalities. There are a number of rivet holes shown black in the side views (the views having the center lines *c d* and *g h*) of both designs. This indicates to the shop men that the rivets destined for these holes are so-called **field rivets**; that is, they are to be driven in at the place where the structure

is being erected and after the columns are in place. The position of the field rivets is indicated in the front views (the views having the center lines *ab* and *ef*) by blackening in the *position* of the holes. According to the rules of drawing, their position would be shown by dotted lines, but the conventionalism of blackening in is resorted to as better calling the attention of the workmen to the fact that the rivets destined for these holes are field rivets. This common usage is departed from only in the case where the parts through which the field rivets pass are hidden behind some other parts of the structure. Thus, referring to the front view of Fig. 1, field rivets are shown as passing through the plate and two angle irons at the splice, and as neither the plate nor the angle irons are hidden, their position is shown in black. In the side view, however, the horizontal plate at the splice is hidden behind the splice plate, and the angle irons are hidden behind the splice plate and the legs of the channels; consequently, the field-rivet positions are shown in this view by dotted lines.

All the rivets that are to be driven in the shop where the column is made are shown in position; in some drawing rooms, in order to save time, the rivets are omitted, their position being merely indicated by two center lines. In order to show the rivets clearly, their heads are shaded a little in the manner shown, using the bow-pen for the shading.

The dimensions of the channels, **I** beams, and **Z** bars are not given in detail, this not being necessary on a working drawing. All that is required is to give the size of the channel, etc. The notes giving the sizes are read as follows: On the front view of the left-hand design we find a note " $2-15''-33-22'-7\frac{3}{8}''$ **C**"; this means two 15-inch channels, 33 pounds per foot of length, $22'7\frac{3}{8}''$ long. The note on the front view of the right-hand design, " $4-6''\times 3\frac{1}{2}''-22.7-$ **Z** Bars," means that four **Z** bars having a depth of 6 inches, legs $3\frac{1}{2}$ inches wide, and weighing 22.7 pounds per foot of length are to be used. The note, " $2-12''-40-$ **I** Beams," means that two 12-inch **I** beams weighing 40 pounds per foot of length are to be used. The note, " $4''\times 3\frac{1}{2}''\times \frac{7}{16}''\times 11\frac{1}{2}''$ Angle,"

means that an angle iron with legs measuring 4 inches and $3\frac{1}{2}$ inches, $\frac{7}{16}$ inch thick, and $11\frac{1}{2}$ inches long is to be used.

In order to aid the student in drawing the various parts the dimensions of which are not fully given on the plate, sectional views of them, fully dimensioned, are given in Fig. 5 of the text.

The section of the 10-inch **I** beam is given in Fig. 5 (a), of the 12-inch **I** beam in Fig. 5 (b), of the 15-inch channel in Fig. 5 (c), and of the **Z** bar in Fig. 5 (d).

In Fig. 5 (a), (b), and (c), the dimensions are given in decimals, or as they appear in the catalogue of the rolling mill. Since it is practically impossible to lay off these decimal dimensions to a scale of $1\frac{1}{2}$ inches = 1 foot, it is recommended to use the nearest sixteenths of an

inch, taking $.19 = \frac{3}{16}$, $.24 = \frac{1}{4}$, $.28 = \frac{1}{4}$, $.31 = \frac{5}{16}$, $.40 = \frac{3}{8}$, $.41 = \frac{7}{16}$, $.46 = \frac{7}{16}$, $.56 = \frac{9}{16}$, $.66 = \frac{11}{16}$, $.67 = \frac{11}{16}$, $.86 = \frac{7}{8}$, $.90 = \frac{7}{8}$.

All rivets in these two designs are $\frac{3}{4}$ inch diameter, having a head $1\frac{1}{4}$ inches in diameter and $\frac{1}{16}$ inch high. The holes to receive the rivets are generally punched $\frac{1}{16}$ inch larger than the shank of the rivet (the size of a rivet is denoted by the diameter of the shank *before* the rivet is

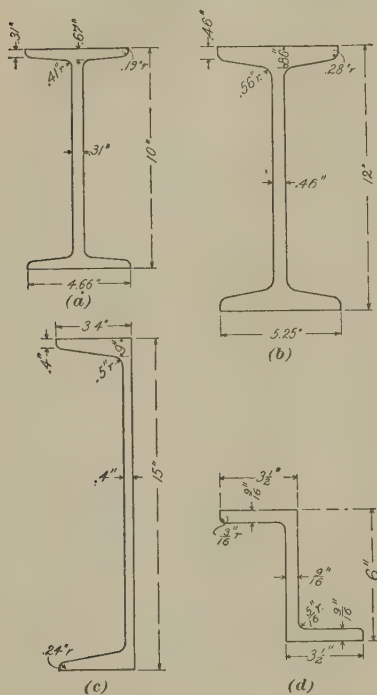


FIG. 5

driven), so that the rivet holes for $\frac{3}{4}$ -inch rivets are punched $\frac{13}{16}$ inch diameter. As a matter of course, the rivet when driven fills the hole, so that the *driven* size of a rivet = nominal size $+\frac{1}{16}$ inch.

To draw the plate, begin by drawing the center lines, locating $a b$, $c d$, $e f$, and $g h$ respectively $2\frac{7}{16}''$, $6\frac{1}{4}''$, $10\frac{11}{16}''$, and $14\frac{9}{16}''$ from the left-hand border line. The top line $K L$ of the floorbeams is to be located $7\frac{5}{16}''$ and the bottom $i j$ of the bases $\frac{15}{16}''$ above the lower border line. The floorbeams are shown broken off, and should be made about the same length in proportion to their depth as they appear on the plate.

The reference letters printed in bold-face italics are to be omitted on the drawing made by the student.

DRAWING PLATE, TITLE: FIRST-STORY PLAN

13. The five following plates will be devoted to the general drawings and details of a **two-story brick-and-frame suburban residence**. The next plate, the **first-story plan**, is to be drawn to a scale of $\frac{1}{4}$ inch = 1 foot. This is what is called a *working drawing*, and shows the form in which a house plan should be drawn and figured, in order to estimate the material and erect the building.

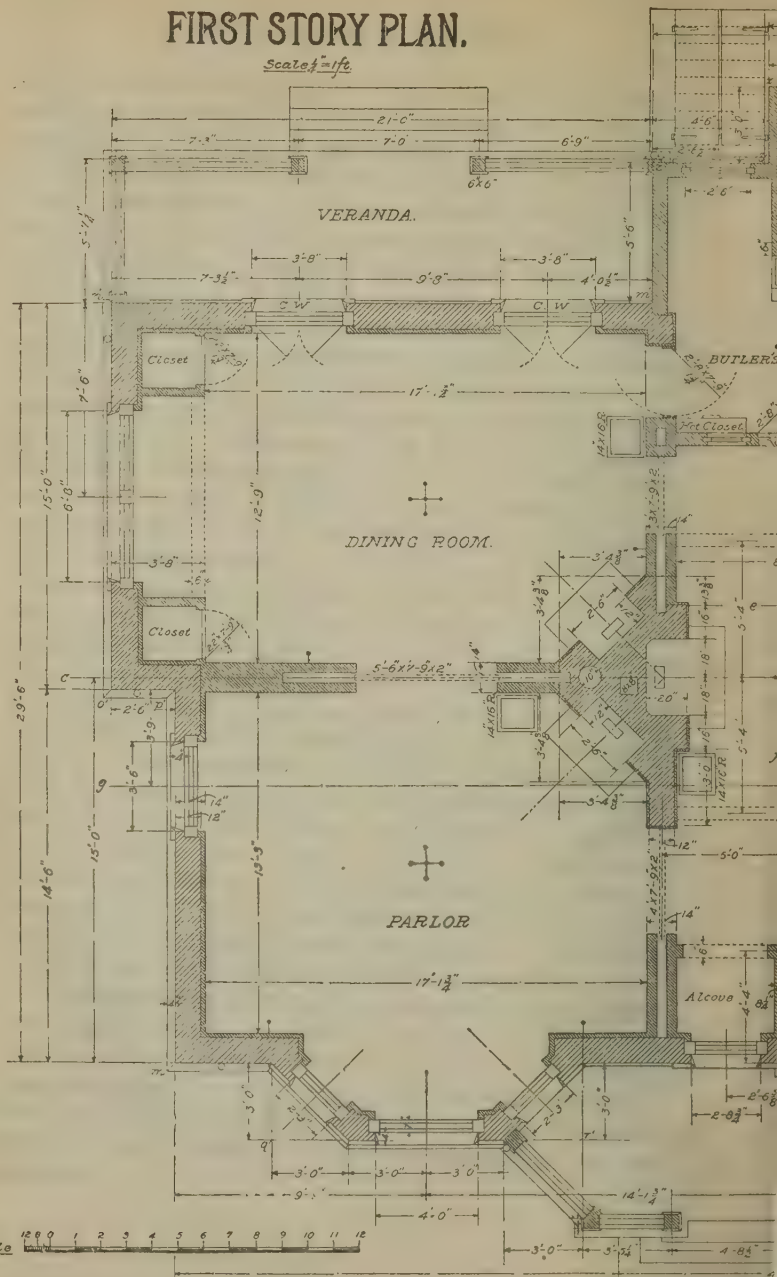
Begin by drawing the center line $a b$ at a distance of $8\frac{1}{2}$ inches from, and parallel to, the left-hand border line; draw the center line $c d$ at right angles to it and at a distance of $6\frac{1}{8}$ inches from the lower border line; then draw the center line $e f$ parallel to $c d$ and at a distance from it, by scale, of 2 feet $9\frac{1}{2}$ inches. These center lines will constitute the base lines of measurement, from which the arrangement of the plan will be developed. Measurements from these lines to locate points must always be on a line at right angles thereto. To locate the exterior angles of the building, proceed as follows: Beginning with m , measure 15 feet from center line $c d$, at right angles to it, and draw the face line $m n$ of front wall; then from a point 23 feet $10\frac{3}{4}$ inches from center

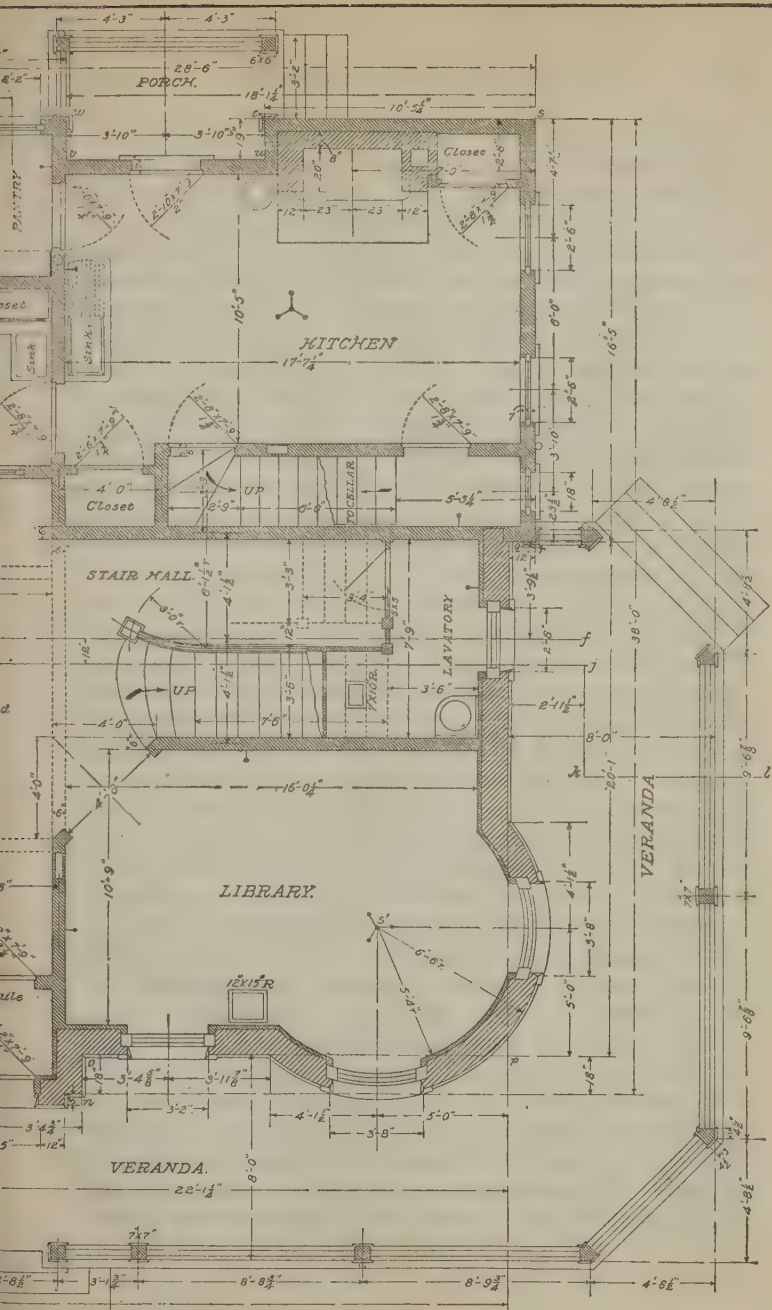
line ab , draw the face line of the return wall mp' ; the intersection of the two face lines will locate angle m . The lines should first be drawn to an indefinite length, their limits being defined as the angles are located. At a distance of 5 feet $7\frac{1}{4}$ inches from center line ab , locate n on the face line of front wall; from n draw line no at right angles to line mn , and at a distance of 18 inches from, and parallel to, line mn draw the face line op of wall. Locate p at a distance of 22 feet $1\frac{1}{4}$ inches from center line ab . From the point p just found, draw the face line of the wall pq at right angles to line op for a distance of 20 feet 1 inch; thence, at right angles to line pq and parallel to line ef , lay off a distance of 12 inches to r . Draw face line of wall rs parallel to center line ab , s being at a distance of 16 feet 5 inches from r ; then draw face line of wall st 10 feet $5\frac{1}{4}$ inches long and parallel to center line ef . At t the wall recedes 19 inches; draw tu at right angles to line st ; draw uv parallel to st 7 feet 8 inches long from angle u ; draw vw equal and parallel to tu ; draw wx in line with st , and lay off x 5 feet $10\frac{3}{4}$ inches from w . Draw face line xy parallel to center line ab , locating y 3 feet from x ; from y draw face line yz parallel to center line cf , z being 4 feet 6 inches from angle y . From angle z parallel to center line ab draw face line of wall zm' , m' being at a distance of 5 feet 6 inches from angle z . From m' draw the face line of wall $m'n'$ parallel to center line cd , n' being at a distance of 21 feet from angle m' . From n' draw face line of wall $n'o'$ parallel to center line ab , o' being at a distance of 15 feet from angle n' . From o' draw face line of wall $o'p'$ parallel to center line cd , p' being at a distance of 2 feet 6 inches from angle o' . The intersection of line $o'p'$ with line $p'm$ will locate angle p' .

The angles defining the main outline of the building being now located, proceed to establish the face lines of the bay window in the parlor and the curved wall of the library. Draw the center line of the bay window at a distance of 9 feet 9 inches from, and parallel to, face line mp' ; then draw front face line of window 3 feet from, and parallel to, face line mn .

FIRST STORY PLAN.

Scale $\frac{1}{4}$ " = 1 ft.





At a distance of 3 feet from each side of the center line, and on the face line of window, locate the angles. At a distance of 6 feet from each side of the center line locate points q' and r' , and draw from each of these points a line at right angles with face line mn ; the intersection of these lines with mn will form the *recentering* angles of the window. To locate the center from which the curved wall of the library is described, measure 5 feet on the face line of wall op from angle p and mark a point; on face line pq measure 5 feet from angle p and mark a point; from each of these points, and at right angles to the lines on which they are marked, draw an indefinite line; these lines will intersect at s' . From s' as a center, with a radius of 6 feet 6 inches, describe an arc which will intersect the face lines op and pq as indicated. Now draw the face line and returns of the entrance doorway. The face line advances 5 inches from the wall-face line mn . Draw the center line of doorway parallel to and 2 feet $2\frac{1}{2}$ inches from the center line ab , and locate the jamb stones as shown; the width of the opening being 3 feet 5 inches, the distance of each jamb from the center line will be one-half of this, or $20\frac{1}{2}$ inches. Make the width of each jamb on the face line 12 inches, and draw in the returns at right angles from the face line. The complete outline of the building proper being now finished, draw the inner face line of all the walls already outlined, noting carefully that the thickness given for brick walls is 12 inches, and for timber walls 7 inches. (The thickness of brick walls varies from 12 inches to 13 inches, according to the size of brick used. The former is here adopted.) Set the bow-pencil to 12 inches by scale, and draw a quadrant arc at the angles m, n, o, p, q , etc., taking the vertex of the angle as the center; tangent to these arcs and parallel to the face lines, draw the inner face lines of walls. The intersection of these lines will define the interior angles. The position of the plaster line in the rooms should be determined in the same manner by increasing the radius to describe the arcs to 14 inches, which will be an allowance of 2 inches for furring and plastering. The width of the clear opening for

the bay window being 9 feet 6 inches, measure 4 feet 9 inches from each side of the center line; this will give the reveal line which intersects with the side wall of window. Follow the same method for laying off the thickness of timber walls, which is 7 inches, of which 5 inches is allowed for the wall studs, or uprights, 1 inch for outer boarding, and 1 inch for plastering. It will be observed that, at the junction of the timber walls with the brick walls, a recess is formed in the brickwork to allow the timber wall to pass over it; this forms an air-tight connection and a secure joint.

Having finished the outer walls, proceed to locate the inner walls, or *partitions*, as they are called. Draw the center line of the partition to the left of the center line ab , 5 feet from and parallel to it. Since this partition is 14 inches thick, lay off 7 inches on each side of the center line, and draw the face lines of partition parallel to the center line. Now draw the brickwork of the chimney construction, first laying off the dimensions on each side of the center line cd to locate the fireplace in the hall; after which mark off the width of brickwork, which extends into the rooms from the face of the partition 3 feet $4\frac{3}{8}$ inches, as shown. Make this line parallel to center line ab , and on it lay off on each side of cd a distance of 3 feet $11\frac{3}{8}$ inches, drawing through the extremities lines parallel to the center line cd . From the points of intersection of these lines with the walls, draw the face line of the room fireplaces at an angle of 45° ; on each side of the diagonal that defines the center line of the fireplaces, lay off one-half of the opening, which will be 15 inches. Make the depth of the fireplace 12 inches, and draw the position of the ash chute in each fireplace and the flues in the brickwork, the flue, which is 10 inches in diameter, being a hot-air duct, and the $8'' \times 8''$ flue being for the furnace in the cellar. Draw, also, the outline of the hearths, taking sizes with the dividers, which, applied on the scale at the bottom of the drawing, will give the measurement. It will be observed that the wing wall of the brickwork is extended to the jamb of the parlor doorway, while on the opposite side the wall is constructed to form the pocket for the sliding door. The

line which is drawn 1 inch from face of brickwork indicates the face line of plastering. Now draw the partition between dining room and parlor, the face lines of which will be 7 inches from the center line cd , and also the partitions enclosing the closets in dining room to dimensions shown; the dotted lines connecting same denote the ceiling beam overhead.

No door or other openings should be located in the partitions until they are all drawn in. Now draw the center line of the hall and kitchen partition to the right of the center line ab , which, as shown, is 4 feet 8 inches from ab ; from this line, lay off on each side 3 inches, which is one-half of the thickness of the partition, and draw the face lines parallel to ab .

Now draw the center line of the partition in which the vestibule door is located, which in this case is 4 feet 4 inches from outer face line of wall, and lay off the face lines of partition by the process already described; afterwards draw the vestibule partition parallel to center line ab . Then draw the center line and locate the partition between the butler's pantry and hall from the dimensions given, and also draw in the partitions that enclose the pantry. Now locate the ceiling beams in the hall, which are denoted by the dotted lines on the plan. From the center line ef lay off on each side, at a distance of 4 feet $1\frac{1}{2}$ inches, the center lines of the stair-hall partitions, and make these partitions of the thickness shown. Now draw the partitions enclosing the kitchen stairway from the dimensions given, first locating the center lines, afterward drawing the partitions enclosing the two closets in the angles of the kitchen, as shown. Then draw in the brickwork of the kitchen-chimney construction, first locating the center line of the fireplace 7 feet from and parallel to the outer face line of the wall, and lay off the face line of the fireplace 2 feet 10 inches from the outer wall face, on which mark the jamb lines 23 inches from the center line, and their width on the face of 12 inches. From the face line of the fireplace lay off the depth 20 inches, drawing the jamb lines parallel to the center line, and make the thickness

of the back wall 8 inches, which will bring the brickwork against the studs of the framework of wall, as shown. Increase the width of jamb in the closet, and construct an $8'' \times 8''$ flue, the least thickness of the wall shown being 4 inches. This flue is arranged for the laundry stove.

Having now finished the outline of the partitions, proceed to locate the door openings in them; where they are on, or adjacent to, center lines, always measure from them; otherwise, find their positions from the angles of the room by the dividers, which, applied to the scale on the engraving, will establish their correct position on the drawing. First find the position of the jamb next to the adjacent angle, set the dividers to the width of the door, and lay off the opposite jamb. Note carefully that the center line of the sliding-door opening between dining room and parlor is in line with the center line of bay window; that the center of vestibule door is in line with that of the entrance doorway; that the center line of the door opening between hall and library is the diagonal, drawn at an angle of 45° from the intersection of the hall side of the partitions. The center line of the door to butler's pantry is on the center line ab ; the center line of the door from hall to parlor is midway between the ceiling beam and the vestibule partition. It will be observed that the jambs for folding doors are rabbeted, or checked, for the full thickness of the door, so that the opening is 1 inch less than the width of the door, that is, $\frac{1}{2}$ inch advance on each side. After the openings for folding doors are located, draw in the arcs with dotted lines, as shown, defining the edge on which the door is hung, and draw in the full line denoting the open door, as shown, at an angle of 45° from the wall face. The size and thickness of doors are not to be written in until all the line work is completed. The double-action door between the butler's pantry and the dining room is shown with a large arc, which denotes the double swing of the door. Draw in the position of sliding doors in their respective openings with dotted lines and the pockets in partitions for their reception, and draw the sash openings on each side of hall door to butler's pantry, as shown.

Having completed the openings in the partitions, proceed to draw the main stairway. First draw the center line of the straight portion of the hand rail of the first flight, which is 3 feet 6 inches from and parallel to the face line of partition. From this center line lay off the center line of the rail of return flight, which is 12 inches from it and forms what is called the *well* of the stairs. Then draw the center line of the platform newels, which is 3 feet 6 inches from, and parallel to, the wall face. From this center line measure a distance of 7 feet on the center line of the first-flight hand rail, and mark a point. This will define the limit of the straight portion, or tangent. At this point erect a perpendicular line, on which lay off a distance of 6 feet $1\frac{1}{2}$ inches. With this length as a radius, describe the curved center line of hand rail, as shown; at the point where the curve leaves the tangent, with a radius of 3 feet, describe an arc intersecting the first curve, which will define the center of the start newel, which is 7 inches square. Draw this newel by first describing a circle 7 inches in diameter; then draw the square outline. The face against which the hand rail abuts will be on a radial line of the first curve. Draw the adjacent faces perpendicular to it, and the opposite faces parallel to it. Now locate the platform newels and the newel at the floor landing, which are 5 inches square, by describing circles 5 inches in diameter, and then circumscribing squares. It will be observed that the center of the newels is at the intersection of the riser lines with the center lines of the hand rail. Next draw in the lines that represent the risers. Beginning at the center line of the platform newels, lay off, with the dividers set to 10 inches, the width of step, or tread, between riser and riser, on the center line of the hand rail of the first flight, a series of points, as far as the straight risers extend. From these points draw in the riser lines at right angles to the center line of the hand rail and project them over to the second flight, as shown. Now draw the curved riser lines by first locating their intersection with the curved center line of the hand rail, and then draw a line in the center of the width of the stairs, finding their width on this

line by applying the dividers to the scale on the engraving. Mark these points on the drawing; then mark the points that define the width at the partition line. Three points having been plotted for each curved riser, join them with an irregular curve. Draw the outer line around the start newel, which indicates the base on it, and from the center line of the hand rail lay off the fine lines that indicate the members of the hand rail. Draw them parallel to the center line. Break off with an irregular line, as shown, which denotes the finished stair broken off to allow the floor arrangement underneath to be shown. Draw in the paneled partitions that enclose the lavatory, including the doorway. It will be observed that the stair lines beyond this break are shown in dotted outline, which denotes that they are represented in a plane occupying a higher level than that on which the other objects are shown. The representation of this stairway is now complete so far as the requirements of the floor plan are concerned. Now draw the portions of the stairway from kitchen to landing level of main stairway and the stairway to cellar as shown. Begin by locating the first rectangular step at a distance of 2 feet 9 inches from and parallel to the partition opposite. Then lay off 6 feet from the step, dividing this line into eight equal parts. From the points marked, draw in the riser lines parallel to the first step drawn, or perpendicular to center line *ef*. Draw in the irregular line, which forms a break in this flight to allow a portion of the cellar stairway to be shown. As the risers of the cellar stairway are on the same plane as the upper stairway, the same lines will serve for both stairways. This will appear clearer when the second-story plan is drawn. Observe, however, that the width of the cellar stairway is reduced $1\frac{1}{2}$ inches, owing to the extra thickness of the brick partition in the cellar. Now draw the risers of the winding treads; find the larger width at the wall faces by the dividers applied to the scale on the engraving, and mark the points on the drawing. Next find the width of the door jamb by the same process, and mark the points on the drawing. Connect these points with those previously found, to

indicate the riser lines. The first riser will be immediately behind the door, and as there will be no nosing on this tread, the riser line will be in the position shown. The arrows indicate the direction towards which the stairs ascend.

Now locate the door and window openings in the exterior walls. Begin with the bay window. The front opening being 4 feet wide, take 2 feet on each side of the center line; mark these points on the face line of the wall. Next draw the window-frame lines, which indicate its thickness; the outer line of frame, being 4 inches in from the outer face line of the brickwork, forms on the jamb what is called the **reveal of the opening**. Mark this point and another point to indicate the thickness of the frame, which is 7 inches. Through these points draw two parallel lines. Now draw the reveal lines at each side of the opening. It will be observed that the window frame passes 3 inches into the wall beyond the reveal line; or, in other words, the width of the window frame is 6 inches wider than the daylight opening in the brickwork. Mark this 3 inches on each jamb and erect a perpendicular line extending to the full thickness of the brickwork. This will form a check in the jamb, which will allow the frames to be put in, after the brickwork is erected, if desired, or to be taken out and renewed when necessary. Now draw the jamb line of the window frame, which advances 2 inches from the brick reveal line on each side; divide the width of window frame into three equal parts and draw in two parallel lines between the jamb lines, as shown. The jambs of window frames are called **pulley stiles**, as the pulleys that the sash cords work over are located near the top of them. It will be observed that the furring and plastering space of 2 inches finishes against the frame forming the inner reveal, but, instead of the plastering, it is usual to insert wooden jamb linings, which assume the position of the plastering. Now draw the side openings of the bay window, locating them by the diagonal lines that are on the center lines of the openings, and fill in the window frames by the method explained in detail for the front window. Now locate the center lines of all the window openings in

the brick walls, from the lines and dimensions given on the plan, and draw the openings in the brickwork from these center lines; fill in the window frames and the inner reveals. In drawing the window openings, starting at the bay window, work towards the right and follow around the wall, finishing them in regular order before starting those in the other walls. It will be observed that the frames in the curved wall are curved on the plan, the lines being described from the center s' , and that the jamb lines of the frames are parallel to the radial line at the center of the opening; this makes an allowance for the insertion of the sash from the inside. If the jambs were made perpendicular to the tangent of the curve, that is, parallel with the brick reveals, the sash could be put in place only from the outside, and further, the frames could not be renewed without cutting out the brickwork. The dining-room windows opening on the veranda, marked *C. W.*, are shown with folding sash, opening inwards like the door openings. These are called **casement windows**, and extend down to the floor. After the window openings in the brick walls have been located and their frames drawn in, locate the stone window sills, which project $1\frac{3}{4}$ inches beyond the face of wall and extend 4 inches beyond the jamb line, so that they are 8 inches longer than the width of opening in the brickwork, the top of the sill between the jamb lines being worked to a sloping surface to shed the water. This is indicated by the miter lines at each jamb, these miter lines being the intersection of the sloping surfaces, or inclined planes. It will be observed that the sills of the bay window are resolved into a sill-course, which is continued around to the main wall. Now draw the door opening of the vestibule. Observe that the door frame passes into a check in the brickwork 1 inch beyond the reveal line, and that the frame is shown rabbeted, or checked, to receive the door. The door sill is in line with the water-table, which projects $1\frac{1}{4}$ inches beyond face line of wall, and at this projection is continued along the walls which are enclosed with verandas. Draw this line and the miter lines at the angles, as the projecting portion is cut to bevel off

1 inch, forming a slope, or *wash*, as it is called. Where the walls are not enclosed by the verandas the water-table projects 4 inches. Draw this line where shown, and miter lines at angles, since the upper surface is sloping. This will be better understood when the elevation and sections are projected.

Having completed the opening in the outer brick walls, proceed to draw in the window and door openings in the outer frame, or wooden, walls. Locate the center lines of the openings from the measurements given, and lay off the jamb lines, which will be one-half of the width of opening from the center line. Divide the width of the jamb, which is the thickness of the wall, into three equal parts, and through these two points draw lines parallel to the wall face. Form a groove in each jamb as shown, 2 inches deep, and draw another line parallel to each jamb 2 inches towards the center line of openings, and between these lines draw a line parallel to the face of wall. Now draw the line of sill, which is $1\frac{1}{2}$ inches from the face line and extends 6 inches beyond each jamb. This is a conventional method of representing window openings in frame walls on plans drawn to this scale, as the minuteness of the actual parts cannot be clearly shown. Draw the outer door opening of the kitchen, which is shown in a manner similar to the other doorways, with the addition of the sill at floor.

The front and side verandas can now be drawn. First lay off the outer face line of the range of posts along the front, which is 8 feet from the outer face line of wall of library and parallel to line *mn*. Then draw the line perpendicular to it and 8 feet from the outer face line of wall, as shown, for the side range of posts. Now locate the center lines of the intermediate posts and the angles of the angular posts from the dimensions given, starting from the center line *ab*, and marking the points towards the right. To locate these points correctly, proceed as follows: Mark the point for first post, which is 4 feet $8\frac{1}{2}$ inches from the center line *ab*, the center line of the second post being 3 feet $1\frac{3}{4}$ inches from the first. Adding the two distances together, we get 7 feet $10\frac{1}{4}$ inches,

the distance from center line $a b$. Measuring this distance from the center line $a b$, mark the point. This method is more accurate than working from point to point with the scale, and has the advantage that when the point is marked its accuracy can be checked by measuring with the scale the distances between the center lines of the posts. Having marked the points for center lines, erect perpendiculars to the outer face line of posts to define the center lines. As the intermediate posts are 7 inches square, draw a line for each range of posts $3\frac{1}{2}$ inches from and parallel to the outer face line of posts. At the intersections of this line with the center lines already drawn as centers, and with a radius of $3\frac{1}{2}$ inches, describe a circle for each intermediate post; tangent to these circles and parallel to the outer face line of posts, draw the line that will define the inner face line of posts. At right angles with this line draw the adjacent faces. As the rail of balustrade is of the same width as the posts, the outer and inner face lines will be continuous. Having finished the intermediate ones, draw the angular ones. Observe that the width of these posts, measured on the outer face line from the angle, is $4\frac{1}{2}$ inches. On each side of the angle mark this distance and draw the adjacent faces at right angles with the face line. Draw in the pilasters at junction with the frame wall, and let them project $1\frac{1}{4}$ inches from the face line of wall. Now draw the posts to the left of the center line $a b$, first laying off the angular one. Observe that there is a square return of 4 inches. Mark this point and draw the line connecting it with the angle of bay window. At right angles to this line mark a point 7 inches from it, and through this point draw a line parallel to the face line first found; this will define the inner face line for the angular and wall posts; complete them as shown, and draw in the intermediate one next to the center line $a b$. Divide the width of the baluster rail between posts into three equal parts, and through the points marked draw two lines parallel to the face line, which indicate the moldings, etc. on top of the rail; then draw the base lines around and projecting 1 inch from the posts, and mark in the miter

lines, as the edges are beveled. Observe that only a portion of the base can be seen, owing to the overlap of the baluster rail.

Now draw the line indicating the edge of the veranda floor, which projects 4 inches beyond outer face line of posts. Lay off this distance from the various face lines, and draw the line parallel to the face line of posts. Now draw the steps, as shown, the riser lines being parallel to the face line and the returns being at right angles therewith. Observe that the first step down at the entrance doorway cuts into the veranda floor, the riser line being on the center line of the posts adjacent, and the treads being 10 inches wide. Mark a point 2 feet 6 inches from first riser, and, drawing a line between these points and dividing the distance into three equal parts, draw in the lines. This will insure accurate plotting. Observe that the ends of the first step are in line with the base lines of posts. Draw the ends and return the other steps as shown. To draw the rear veranda and kitchen porch, follow the method just given, observing, however, that the posts are 6 inches square instead of 7 inches.

Draw the lines that indicate the door leading to the cellar, locating the points by scale measurements from the engraving, and also the dotted lines, which indicate the steps. The exterior work being completed, draw in the lines representing the kitchen range, boiler, sink, and drip board, and the position of the refrigerator and shelving in the pantry. The two circles enclosed in the angle of the partition indicate the position of the pipe lines to the bathroom overhead. Then draw the china-closet sink and hot closet in the butler's pantry. The china closet is shown with doors, and the line in front of it indicates the edge of the cabinet underneath. Draw the corner wash basin in the lavatory, as shown. Bisect the angle with a line, which will make an angle of 45° . On this line locate the center, describe the circle which indicates the basin, draw the surrounding line which indicates the basin slab, and also the parallel lines at the walls indicating the vertical slabs. Having finished these various fittings, proceed to locate and draw the registers, which are

placed over the hot-air ducts to the several apartments, where shown, first drawing in the center line and marking the outline to agree with the figured sizes, as 12 in. $\times$ 15 in., shown in library. These hot-air ducts constitute only a portion of the system of heating required for this building, the direct radiators not being shown in the plan, as their insertion does not affect the building construction, as does the hot-air duct system, for which provision must be made in the construction of the floors and partitions. Now draw the ducts leading to the second floor, which are located in the partitions, as shown. After the ducts are drawn, proceed to indicate the position of gas fixtures. Where they are located in the center of the rooms, draw diagonal lines from corner to corner, the intersection of which will be the center of the ceiling fixture. On this as a center, with a radius of 7 inches, describe a circle, dividing it into the number of parts required to designate the number of burners that will be on the fixture, which are indicated by the small circles. At the center of the fixture make a similar circle, and draw the lines radiating from the center to each burner. Observe that the center of the fixture in library is located on the center from which the curved wall is described.

Having completed the ceiling fixtures, locate and draw the wall fixtures where shown, the center being 5 inches from wall surface. Now locate and draw in the circles that are shown at intervals against the outer face line of walls and veranda and porch posts, which indicate the position of the rain-water conductors, it being essential to arrange their location on the plan with reference to the cornice projections, central position on wall surface, and other considerations that have to be reviewed in conjunction with the arrangement of the gutter outlets on the various sections of the main and veranda roofs, and is of further value in showing their connection with the drainage system, which is usually shown on the cellar plan. The pencil work now being finished, proceed to ink in the drawing, after which clean the sheet with soft rubber and remove the pencil lines that have overrun at the angles and openings. Draw in and ink the dimension

lines. Write in the dimensions. Ink the original center lines and letter them. Draw, ink in, and letter the line of the cutting plane $g h i j k l$, from which the longitudinal section will afterwards be developed, and letter the names of the various apartments and fixtures. Observe that variations in the size of letters and figures have been made in this plate from the standard sizes, to suit spaces, etc., which is to be followed by the student on his drawing. Take the size by the dividers and apply to the scale on the engraving, which will give the accurate size to put on the drawing. All the information relative to doors, windows, flues, ducts, etc. should be written in full on the drawing; but the reference letters at the angles of the building may be omitted.

DRAWING PLATE, TITLE: SECOND-STORY PLAN

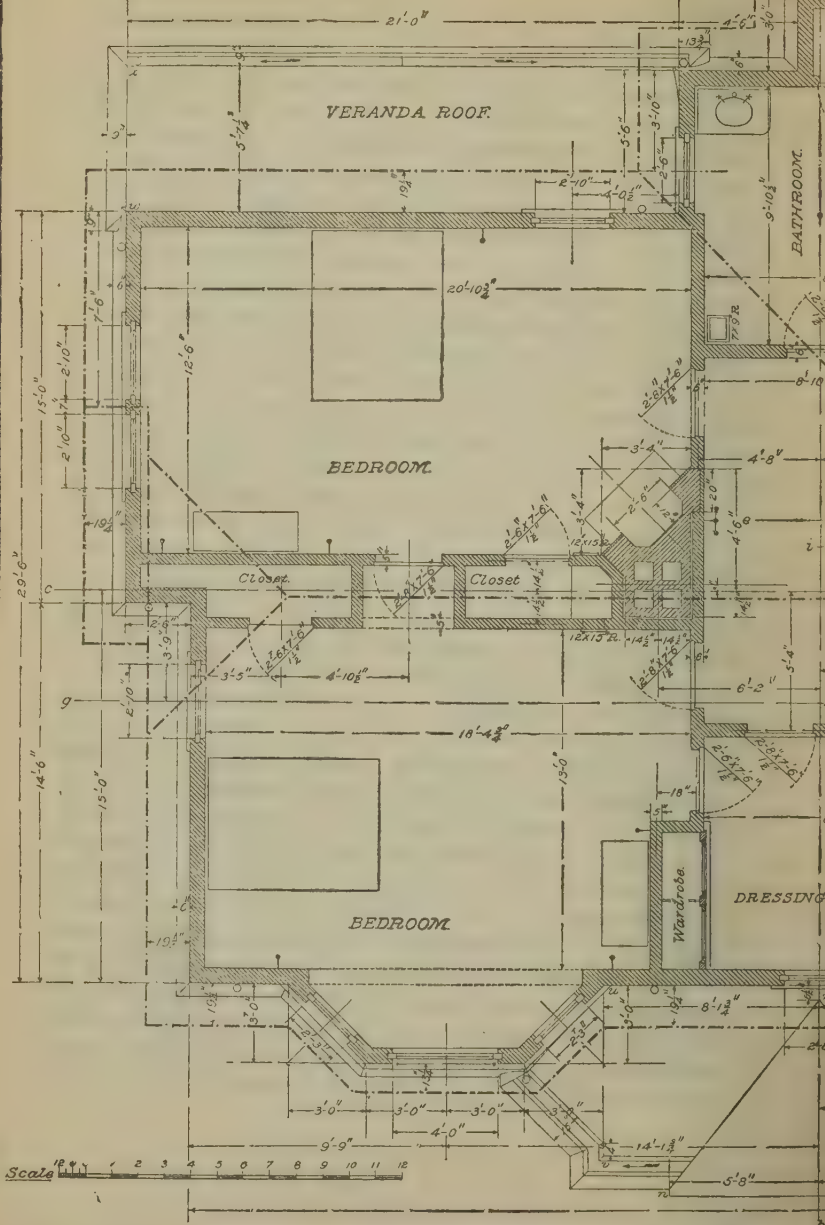
14. This plate shows the **second-story plan**, and is to be drawn to the same scale as the preceding plate, that is, $\frac{1}{4}$ inch = 1 foot.

Begin by drawing the center line ab at a distance of $7\frac{3}{4}$ inches from and parallel to the left-hand border line. Draw the center line cd at right angles to it and at a distance of $6\frac{1}{8}$ inches from the lower border line. Then draw the center line cf parallel to cd and at a distance, by scale, of 2 feet $9\frac{1}{2}$ inches. These center lines, as mentioned in the previous article, will constitute the base lines of measurement, from which the arrangement of the plan will be developed. Proceed by locating the angles on the outer face line of the building, which will define the outline of the plan in accordance with the instructions given for drawing the first-story plan. Then draw the thickness of the outer walls and locate the center lines of the partitions from the measurements given. Draw the partitions that will define the interior arrangement. It will be seen, by comparison of the second-story plan with the first-story plan, that many of the partitions occupy the same relative position as those underneath them, thus affording a continuous construction. Draw the

brick stacks, or chimneys, in which are located the open fireplace and the smoke and ventilating flues. The dotted lines connecting the left-hand flue with the wall surface of the room denote a terra-cotta inlet to the flue for the stovepipe connection, the line beyond the wall surface indicating the collar of the inlet. Draw the door openings in the partitions in accordance with the method followed on the first-story plan. Draw the ceiling beams, indicated by the dotted lines, spanning the recesses in partitions and forming the subdivision of the ceiling between hall and stair hall, and the ceiling beam at the bay window. Now draw the main stairway. Observe that the platform and landing newels are the same as those shown on first-story plan, but in this case the dimensions given to center line of newels, 4 feet 8 inches, is taken from the outer face line of timber wall. Draw this line; mark the distance from center line of newels to center of landing newel, 3 feet 4 inches, and the distance, 9 feet 2 inches, to center line of newels at the start of second stairway, which leads to attic. Draw in these lines, which also indicate the riser lines. Now draw the center line of the hand rail of each flight, locating it from the face line of partition walls, by the measurements given, and draw parallel to center line *ef*. At the intersection of these center lines with the riser lines, which gives the center of the newels, describe circles 5 inches in diameter, and then circumscribe squares, which will denote the newel posts; divide the distance between center lines of newels into the number of spaces shown for each flight, and draw in the lines at right angles to center line *ef*, which will indicate the treads of the stairway, and which are 10 inches wide between the riser lines; correctly stated, the lines shown represent the face line of risers, while the distance between these lines gives the width of tread, exclusive of the nosing, or projecting section of the tread beyond the riser. As the riser lines of the second stairway are immediately over those of first flight, they occupy the same relative position on the plan, the irregular line indicating the break in second stairway, so that the lower one can be seen. Now draw the lines

SECOND STORY PLAN.

Scale $\frac{1''}{4} = 1 \text{ ft}$



showing the width of the hand rails, which is 4 inches; measuring from the center line will give 2 inches on each side.

After the hand rails, draw the base lines around the newels, observing that only portions of the base can be seen, as the hand rail, occupying a higher plane, overlaps it. Draw the arrows, which indicate the direction followed by the flight. Having completed this stairway, draw the section of stairway to kitchen, which is exposed by breaking off the closet floor, as shown. Locate the first riser, which is 5 feet $5\frac{1}{4}$ inches from outer face of wall, as shown on first-story plan. Make the width of treads the same as shown on first-story plan. Observe that there is a riser line shown at the door opening on the platform of main stairway, which indicates that the platform is higher than the landing of kitchen stairway. This can be verified by counting the number of risers in each stairway up to the platform level.

Now locate and draw the window openings in the exterior walls, first locating the center lines and drawing the jamb lines, etc. by the method given for those on the first-story plan. Notice that the window sill is continued as a table course around the bay window, supported by a bed mold and fascia, which will be shown on the elevation in a subsequent plate. In wood construction the sills are either worked with a sloping upper surface, to shed the water, or the sill canted for that purpose, so that there are no wash miters to show on plan, such as there are in stone construction.

After the window openings are completed, proceed to draw the veranda and porch roof. Beginning with the front and side verandas, first locate and draw the outer face line of the beam, which is supported by the posts, and is 8 feet from and parallel to the straight-line wall surfaces. This line having been drawn, locate the angles where the line changes direction, from the measurements given. Reference to the first-story plan will give the student a better understanding of the position of this line, as this forms the base line from which subsequent measurements are taken. Parallel to this line, and at a distance of 15 inches therefrom, draw the line

of the eave, or horizontal cornice projection. Next draw the pediment, or low-pitched roof, over the front-entrance section of the veranda. Observe that the center line of the ridge is on the center line ab . On each side of the ridge lay off the distance shown of 5 feet 8 inches, which will give the point of intersection of the valley of the pediment roof with the eave line of veranda. On the center line ab , at a distance of $6\frac{1}{2}$ inches from the face line of wall, mark a point. From this point draw the lines of the valleys mn , mo on each side of the center line ab to the point on the eave line already found. A valley is the line of intersection of the inclined surfaces of two roofs, the eave lines of which form an interior angle. Draw the cornice projection of the pediment, which advances 3 inches in front of, and is parallel to, the eave line already drawn. From the point of intersection of each of the valleys with this eave line, and at right angles thereto, draw the eave lines of the pediment.

Now draw the center lines of the parapet walls of the balcony, which surround the stair-hall window. As shown, the center line of the front wall is 2 feet $11\frac{1}{2}$ inches from the outer face line of wall of building, and is parallel to it. The center lines of the return, or end, walls are each 4 feet $\frac{1}{2}$ inch from the center line ef of the window. The width of the coping being 11 inches, lay off $5\frac{1}{2}$ inches on each side of these center lines, and draw the edges of the coping. The second line from the edge of the coping of front wall on the inside indicates the width of the balcony gutter. The dotted lines that cross the wall at the end indicate the weeper, or gutter outlet. The curved line in advance of the parapet line represents the intersection of the curved section of the parapet wall with the inclined surface of the veranda roof. The line from the angle at eave line to angle of coping shows the miter line of the curved surfaces of the front and return wall. Now draw the lines denoting the gutter which is constructed in the cornice. Observe that the inner line is on the beam line, over face of posts already described. The width of the gutter from this line is 9 inches, which space is further reduced 2 inches on each side by the lines indicating

the junction of the sloping sides of the gutter with the bottom, or bed. These lines on the plan are shown parallel with the edges of the gutter, which is the usual course followed on a small scale drawing; but in practice or on a larger scale-detail drawing, these lines will converge towards the gutter outlets, owing to the grade, or pitch, of the bed of gutter. The circles in the gutter show these gutter outlets, and the arrows indicate the descending grade towards them.

Locate and draw the hip lines $p q$, $p r$, $s t$, and $u v$ of the veranda roof. A **hip** is similar to a valley in the respect that it is the line of intersection of the inclined surfaces of two roofs, but with the difference that the eave lines form an exterior angle; in other words, they represent a miter line that is formed by the change in direction of the roof, or inclined plane, and this miter line is resolved into a hip or valley, according to the nature of the angle at the eave lines.

Observe that the hip, or miter lines, are not drawn across the bed of the gutter, since it is a flat surface, miters only being shown where an angle is formed. The bed of the gutter at line $p r$ is thus shown, as the grade, or pitch, changes at this point.

Now draw the rear veranda roof in accordance with the method given above, first drawing the beam line, which is 5 feet $7\frac{1}{4}$ inches from the wall face. The cornice projection from this line is only 9 inches, the cornice at the open end being horizontal, and the line $w x$, following the slope of the roof, forms a half pediment over the cornice. Next draw the porch roof. As here shown, the roof plane is unbroken, except where the gutter is inserted, and is a simple slope from the eave to the wall junction. Circumscribing the wall of the building, where not occupied by verandas and porch, is a line 6 inches from the wall. Draw this line, which shows the projection of a molded course around the building, formed by the corona, or table, of the veranda cornice; miter the angular connections, and carefully observe and draw the connections with the cornices. These connections will be better understood when the elevation and

subsequent plates are drawn. The exterior work being finished, draw the fixtures in the bathroom, consisting of the plunge bath, foot-bath, water closet, and wash basin, first locating the center lines by the application of the dividers to the scale on the engraving, which will give their position on the drawing. The various sizes can be found in the same manner, from which their complete outline can be drawn. The soil and ventilating pipes, which are continued up to and through the roof, are enclosed in the partition wall, which in this case is increased to 7 inches for that purpose.

The circle in the partition adjacent to the stair platform indicates the ventilating pipe from lavatory. Draw the enclosing frame and doors of the wardrobe in the dressing room. The line that advances from the line of frame indicates the shelf, under which a range of drawers is placed. Draw the outlines of the bedsteads and bureaus in the bedrooms, which, in plan making, materially influence the location of the window openings and gas fixtures.

Locate and draw the registers of the hot-air ducts from the positions shown on plan. In the closet adjacent to the four-flue brick stack, a section of the floor is elevated so that branches can be taken from the vertical duct to the wall registers in rooms. Locate the gas fixtures, and indicate in the same manner as shown on the engraving. Draw in the circles that denote the position of the rain-water conductors. The two on the front wall discharge on the roof of the veranda, as also the one adjacent to the rear veranda. The others continue down to the ground line.

The heavy broken and dotted lines indicate the constructive lines of the main roof planes, and will be considered later on.

The pencil work being finished, proceed to ink in the drawing, after carefully cleaning same. Draw in and ink the dimension lines and write in the dimensions, and draw, ink in, and letter the line of the cutting plane *ghijkl*. Letter the names of the various apartments and fixtures, as shown on engraving, and letter the center lines, making the drawing conform with the engraving in all respects, except that the reference letters may be omitted.

Now proceed to draw the constructive lines of the main roof. Begin by drawing the ridge lines. The ridge line parallel to center line cd is midway between the front and rear walls of building, and is therefore 14 feet 9 inches from the outer face line of either wall. The ridge line parallel to ab is midway between the walls of the rear extension, or wing, and is therefore 14 feet 3 inches from the outer face line of either wall. Now draw the cornice projection lines around the building, which are parallel to the face line of walls, and in general are 18 inches from it, except at the bay window, where the distance is $13\frac{1}{4}$ inches; adjacent to the tower two eave lines are shown, which indicate a higher and lower plane, which will be fully understood when the elevation is drawn on a subsequent plate. From the center of the tower, with a radius of 8 feet $1\frac{1}{4}$ inches, describe the circle denoting the cave line of tower. The segment advancing into this circle denotes the intersection with the adjacent roof planes; the center for describing the segment is at the intersection of the ridges.

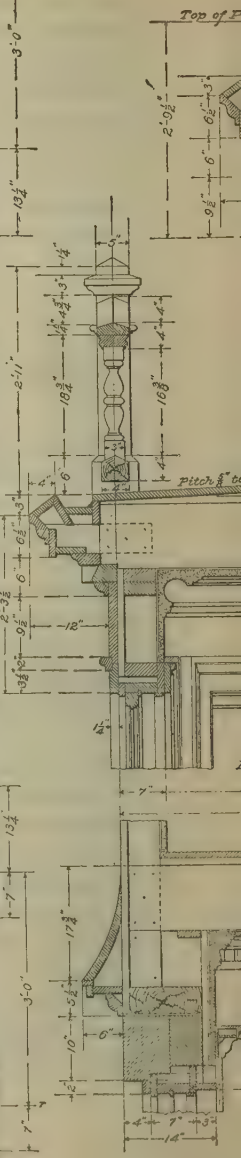
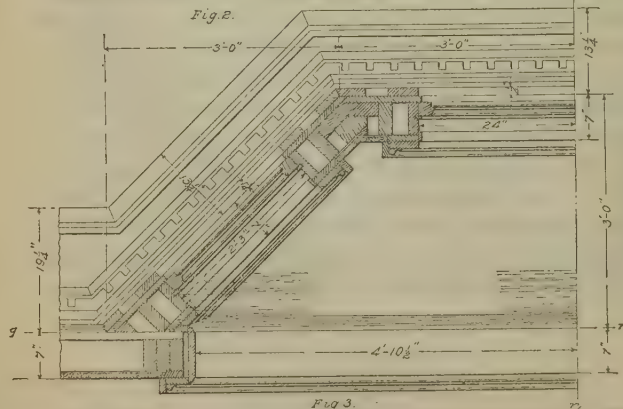
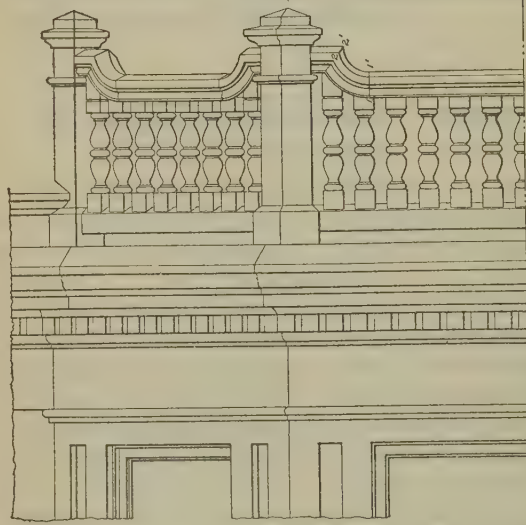
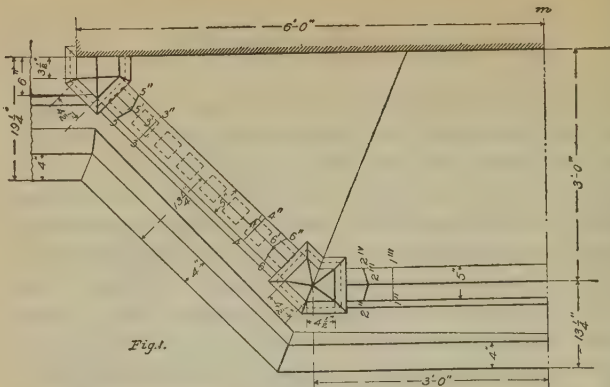
As the eave lines over the rear veranda roof form an interior angle, the line connecting their intersection with the ridge line will be a valley. While this line from the ridge, if continued to the intersection of the straight walls, would meet an exterior angle, and is therefore a hip, the limit of its length in this case is the wall of the tower. The projection of the cornice over the bedroom wing to the left of center line ab indicates a gable cornice, a **gable** being the triangular-shaped wall on the front or side of a building, under the inclined lines of the roof planes. The ridge is shown in the center, and is the intersection of the roof planes that meet on this line. Observe that the main roof gable adjacent to the wing gable just described is **truncated**; that is, a portion of it from the ridge line is cut off to a line parallel with a horizontal line connecting the eaves. The dimensions of the plane formed by cutting off this section can be found on the plan to be 3 feet 9 inches from the wall face to ridge intersection, and the distance from the ridge to the eave intersections 5 feet $4\frac{1}{4}$ inches. The latter

points having been found, connect them with the intersection on the ridge, thus defining the hip lines of the truncated part of the roof. Ink in the roof lines with heavy broken and dotted lines, as shown on the engraving. The point of intersection of the various roof planes will be required in developing the elevation and longitudinal section, and many advantages are obtained by locating the main roof lines on a plan, as an intelligent conception can thus be formed of the requirements of the plan of the building; roofing considerations, in a well-studied plan, very often require its modification to secure a satisfactory design.

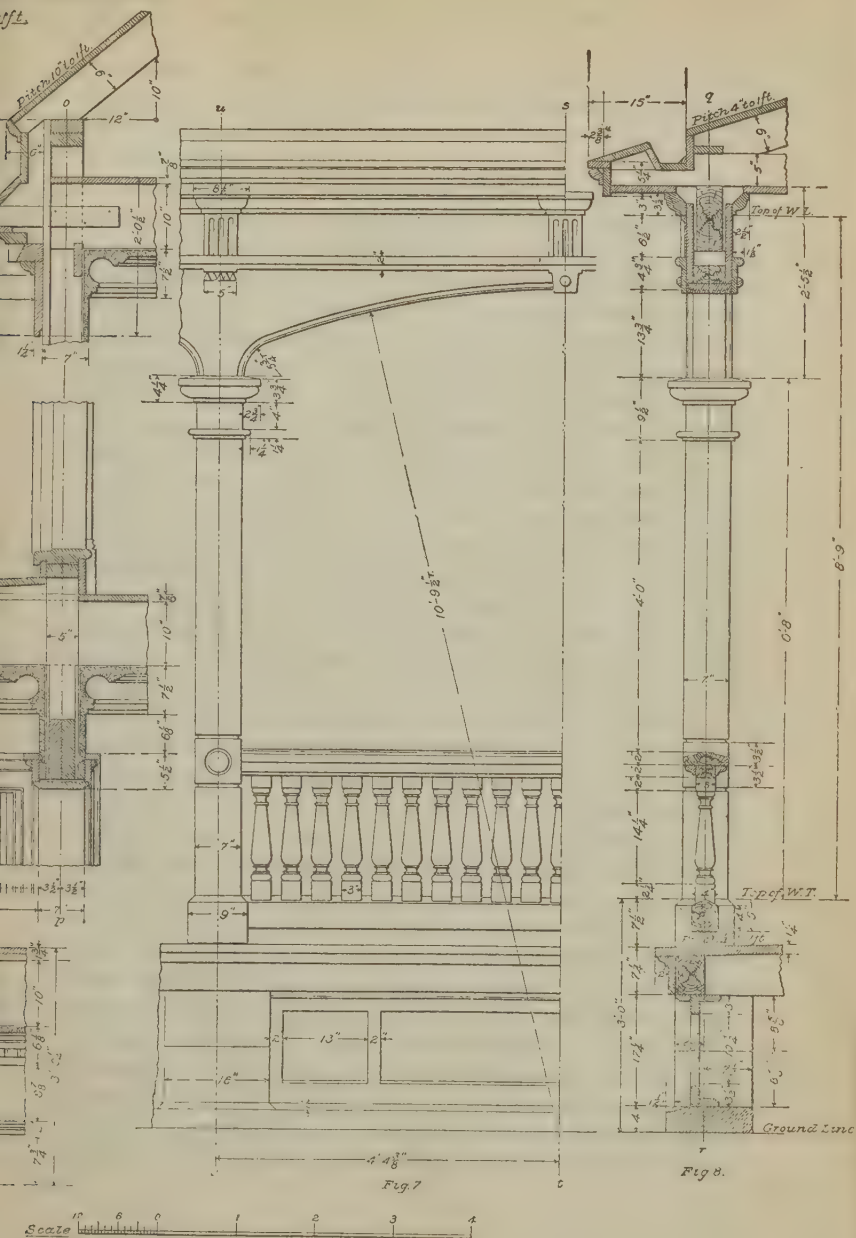
DRAWING PLATE, TITLE: CONSTRUCTIVE DETAILS

15. This plate comprises a number of figures, which are the **details** relative to the construction of various sections of the suburban residence. They are to be drawn to a scale of $\frac{3}{4}$ inch = 1 foot. Figs. 1, 2, 3, and 4 are drawings showing the construction of the second-story bay window, and the balustrade that surmounts it. Fig. 5 shows the construction of the corona and bed mold forming the molded course that circumscribes the building, as shown on the second-story plan, and also shows the construction of the window frame and inside trim, or casing, the plaster cornice of the first-story ceiling, etc. Fig. 6 shows the construction of the main cornice of the building, the plaster cornice of the second-story ceiling, etc. Figs. 7 and 8 are, respectively, a sectional elevation and a vertical section of the front veranda.

In developing Figs. 1, 2, 3, and 4, which pertain to the bay window, the several portions of each require to be drawn in successive order, so as to obtain their relative position in each figure. Begin by drawing the center line mn $5\frac{5}{8}$ inches from and parallel to the left-hand border line; at a distance of $3\frac{5}{8}$ inches from and parallel to the center line mn , draw the center line op , after which proceed to draw Fig. 3, which is a one-half plan of the second-story bay window as seen



THE DETAILS.



served.



from below. This view is taken for the purpose of showing the position of the various members of the cornice, including the dentil course, from which projections will be made in developing Fig. 2.

Commence on Fig. 3 by drawing the outer face line of frame wall qr at a distance of $\frac{3}{4}$ inch from, and parallel to, the lower border line. At a distance of 3 feet, by scale, lay off the face, or sheathing line, of front of the window parallel to qr . On this line lay off a distance of 3 feet from center line mn , and at a farther distance of 3 feet from this point, draw a line parallel to mn , intersecting qr . Connect this point to the point on face line of the window, and the face line of the side window will be defined. Parallel to the front and side lines now located, and at a distance of 7 inches therefrom, draw the lines indicating the width of the window frames. Observe that this width coincides with the face line of the plaster, and is therefore the full thickness of the frame wall from the outside of the sheathing to the inner face of the wall. Now draw the jamb lines of the window frames. The jamb of the front window is 24 inches from, and parallel to, line mn , which will leave a distance of 12 inches, the width of the angle pier on the face line. From the angle, mark a point 12 inches on the side line of the window, and draw the jamb line through this point at right angles to the side line (thus making the side width of pier the same as the front). Then draw the opposite jamb line 2 feet 3 inches from the one just drawn. These jamb lines and others parallel thereto can be drawn by using the 45° triangle on the edge of the T square, as the side line of the window will be found to make an angle of 45° with the face line of wall qr . Now draw the construction of the window frames as follows: Begin with the frame of the front window. Draw the thickness of the jamb, which is $1\frac{1}{2}$ inches; the 7-inch width is then divided as follows: 1 inch for outer lining of window frame, 2 inches for upper sash, $\frac{1}{2}$ inch for the parting strip between sash, 2 inches for lower sash, the remaining space being occupied by the sash-stop bead, which keeps the lower sash in position. The plaster casing of the window frame is 1 inch

thick, which thickness is taken up by lath and plaster. Observe that the edge of the outer lining projects $\frac{1}{2}$ inch in front of the jamb line; that the parting strip is inserted into a groove in the jamb $\frac{3}{8}$ inch deep; that the strip projects $\frac{1}{2}$ inch from the jamb; and that the sash-stop bead is $\frac{1}{2}$ inch thick; so that these three edges are in line with one another and parallel to the jamb. Now draw the width of the sash stile. This width is 2 inches to the glass line, or rabbet, in which the glass is bedded. The rabbet is $\frac{3}{8}$ inch wide, which makes the total width of sash stile $2\frac{3}{8}$ inches. The inner edge of the sash is molded. The rabbet for the glass is on the outside, so as to make it water-tight, which is secured by bedding the glass in oil putty and forming a beveled fillet of putty on the outside, which sheds the water. Now form a box for the sash weights to work in, behind the jamb, by setting the first stud, or upright post, in the wall framing, $2\frac{1}{2}$ inches back of the jamb. Draw the outside casing, which is $1\frac{1}{4}$ inches thick and $4\frac{1}{2}$ inches wide, the angular casing being of the same width. Next draw the inside casing, or trim, which is composed of a facia, or plate, $\frac{7}{8}$ inch thick and $4\frac{5}{8}$ inches wide, against the back edge of which is attached what is called a **back band** $\frac{7}{8}$ inch thick and $1\frac{7}{8}$ inches wide, and in the angle formed is attached a molding $\frac{7}{8}$ inch thick and $1\frac{3}{4}$ inches wide. On the face edge of facia a $\frac{1}{4}$ -inch bead is indicated. Having finished this jamb section of the window frame, draw in those of the side window in the same manner, after which draw the angle post, which is composed of several sections of scantling, or small timbers, so arranged as to break joint and form a solid interior and exterior angle. The angle at junction with wall surface is made secure by a piece of scantling of a triangular section nailed to the wall sheathing. The outer casing at this angle is mitered on the edge against which the ends of the beveled siding or finished wall surface abuts, which will secure the siding in position.

From what has been already stated in connection with this plan, the student will realize that a detail drawing must show *every part in detail*, the various items of construction being duly considered. Each part of the detail must be drawn in

the actual position it will occupy in the finished structure. Drawn to the scale of $\frac{3}{4}$ inch = 1 foot, it therefore represents $\frac{1}{16}$ the actual size.

Now draw the thickness of the main wall 7 inches from, and parallel to, qr ; show the thickness of the sheathing 1 inch and of the lath and plaster 1 inch. At a distance of 4 feet $10\frac{1}{2}$ inches from the line mn draw the jamb line of casing, and finish the wall casings, as shown. The angle post is composed of three thicknesses of $2'' \times 5''$ scantling, on which is attached the plaster ground, with the edge beveled inwards, which tends to bind the edge of the plastering and keep it from springing when the casings are nailed in place. As previously mentioned, this figure is a view from below, so that the head-jambs, head-casings, lintels, and top rails of the sash are seen in full. Therefore, the lines connecting the various sections should be drawn in; they will denote the position of the parts when in place.

Having advanced thus far with Fig. 3, next proceed with Fig. 4, which is a section of the upper portion of the bay window on line mn . Draw the second-story floor line, which is 8 feet $10\frac{1}{2}$ inches by scale from, and parallel to, the lower border line. Draw, 2 feet 6 inches below the floor line, the line of the head-jamb of the window frame. At a distance of 3 feet $3\frac{1}{2}$ inches from the center line op , draw the front face line of the bay window, which is also the line of the window frame. Lay off the width of the window frame 7 inches and draw the head, sash, and inside casing, and the section of the wall that is above the head. The sectioned ends denote the horizontal framing in position. Draw the section of the main wall, which is above the head of casing, and which finishes the opening in the wall behind the bay window, the center line op being in the center of this wall. Observe that there is a section of a beam composed of two thicknesses, spanning the wall opening, which is cased up similar to the inside casing on windows, but instead of the square edge it is finished with a quarter round. This beam supports the wall construction overhead, the studs of which are shown to run down and rest upon it. The beam

is 4 inches in thickness, and it will be noticed that the studs are reduced to this width, and that the vertical strips $\frac{1}{2}$ inch thick are continued down each face of beam, thus securing a rivet for the plaster work from the floor level down. Draw the horizontal lines from the dimensions given. The thickness of the floor is $\frac{7}{8}$ inch; the depth of joist, or floorbeam, 10 inches; the plaster cornice, including the regular thickness for lath-and-plaster ceiling, $7\frac{1}{2}$ inches; the intervening wall surface between *cornice* and *casing*, $6\frac{1}{8}$ inches; and the width of casing, $5\frac{1}{2}$ inches.

Draw in the coves of the cornice with the compasses, scale the members with the dividers, and draw in the moldings, guided by the eye, their projections from the surfaces first being found from the engraving. In order to represent the jamb lines and casings of the side window on this figure, it is necessary to project all these lines forward to the plane represented by the line *mn*, as has been done with the jamb lines adjacent to the main wall, which, transferred to a horizontal line under the figure and projected upwards and intersecting with their respective members, drawn horizontally, will define the jamb lines and casings in their proper position when viewed through the plane on line *mn*. The process of transferring these points is readily done by marking them on the edge of a strip of drawing paper placed on the line *mn*. Marking carefully the position of the main wall, the strip can then be applied on the horizontal line under Fig. 4, first making the wall lines of Fig. 3 coincide with those of Fig. 4 and then marking off the points. This is more expeditious than transferring each space with the dividers, but it requires precise work to secure good results.

Now draw the frieze, the casing of which is $1\frac{1}{4}$ inches thick. At a distance of 12 inches from face of the frieze draw the cornice projection, after which draw a line 2 feet $3\frac{1}{2}$ inches from head-jamb, which will define the top of the crowning member of the cornice. Then lay off the subdivisions of the entablature from the head-jamb line, $3\frac{1}{2}$ inches for the fascia of architrave, 2 inches for the astragal mold of same, $9\frac{1}{2}$ inches for the frieze, 6 inches to the drip edge of the

corona, and $6\frac{1}{2}$ inches for the corona and covering member. Observe that the soffit, or lower face of the corona, is $\frac{1}{2}$ inch higher than the drip edge, which gives a space of $6\frac{1}{2}$ inches for bed molds and dentils. In drawing the moldings and other members, first draw a series of horizontal lines between the main divisions already located, which will define the thickness of the various members. Then draw a series of vertical lines parallel to the center line *op*, and measure the projection of each member with the dividers from the face of the frieze. Having fixed these points, the moldings of the cornice and the bead of the astragal can be drawn with compasses. After the outline is correctly drawn, mark the thickness of the material of which the members are constructed, and their widths, and finish the section of the **entablature**, which is the term given to the assemblage of the parts separately known as the *architrave*, or beam, immediately over the window or door openings; the *frieze*, or upper beam, corresponding in position with the roof construction; and the *cornice*, or projecting table, at the top of a wall, which represents the finish of the roof covering.

Now draw the floor of the balcony over the bay window, the pitch being formed by beveled strips nailed to the floor joists. Form the gutter in the cornice, as shown, and the sill and frame of the door that opens on the balcony.

Draw the thickness of post and the section of balustrade, the center line of which is the face line of the wall sheathing over the window head. Draw this line and draw the horizontal lines that define the base, baluster, and cap rail. Draw the base and cap rail, after which lay off the blocks of the baluster, and the members of the turned section of baluster, by a series of horizontal lines, and draw the curved outline with the bow-pencil, after first carefully locating the position of the centers by vertical and horizontal lines. The height of the post cap cannot be determined until the **ramp**, or upright curve, on the cap rail is drawn.

Now draw Fig. 2, which is a one-half elevation of the upper portion of the bay window, with the balustrade which surmounts it. This is done by projecting vertically those

lines of Fig. 3 which can be seen from the outside of the building (this being an outside elevation); they represent the edges of the outer lining of the window frame, the outside casings, the angle lines, and the sash lines. Now project, from Fig. 4, the entablature lines, the edge of outer lining of the window frame, and the sash lines; the intersection of these with the vertical lines drawn from Fig. 3 will define the head of the window frame, the sashes, and the panelings of the outside casings. Before the miters of the moldings, and the intersection of the cornice lines and the dentils can be located, the horizontal projection of the cornice must be drawn on Fig. 3. From Fig. 4 transfer the horizontal projection of the various members from the frieze line, with the dividers or by means of a strip of paper as before mentioned. Mark these points on the center line mn ; draw the line of extreme projection first, which will be found to be 12 inches from the frieze; now, at right angles to the frieze of the side window, 12 inches from and parallel thereto, draw the side-cornice line of extreme projection; from the intersection of these lines to the angle of the outside casing draw the miter line. All the points of the cornice members can now be projected from the center line mn , forward to this miter line; and, by the use of the 45° triangle on the T square, these lines can be continued across the side window. The angle of intersection of the outer lining of the frame with the face line of the main wall, a recentering angle of 135° , should be bisected according to the method explained in Art. 31, *Geometrical Drawing*; the line of bisection will be the miter for the bed molds, which continue along the main wall. Observe that the projection of the main cornice is greater than that of the bay window, and is $19\frac{1}{4}$ inches from the face line of the wall. Bisect the angle at the intersection of this line with that of the side window; the line of bisection will be the miter for the crowning members of the cornice. Now lay off the dentils, which measure $2\frac{1}{2}$ inches on the face. Begin on the face line of the dentil course at the center line mn , and mark one-half the width, which is $1\frac{1}{2}$ inches; then, at the angle, mark a full dentil. Mark a

point in the center of the width of this dentil, and divide the length of the line between this point and the center line mn into ten equal parts, as explained in Art. 31, *Geometrical Drawing*, which will give the center of each dentil. With the dividers set to $1\frac{1}{4}$ inches, mark the points on each side of center, thus obtaining the width and position of each dentil; draw the line that denotes the depth of the channel between them, which is $1\frac{1}{4}$ inches, and complete the dentils. To locate the dentils on the side window, first mark one-half the width of dentil from each angle and divide the remainder of the line into thirteen equal parts, and proceed as before. Having finished the dentils, project vertical lines from the plan to the elevation, Fig. 2, their position on the elevation being the same as would be seen on the plane perpendicular to the line mn . The intersections of the cornice molds, etc. can also be projected, and the cornice and molds completed on Fig. 2.

Before the balustrade can be drawn in Fig. 2, it will be necessary to draw Fig. 1, which is a plan of the balcony over the bay window as seen from above. Begin by drawing the face line of the attic wall, at a distance of $\frac{3}{4}$ inch from the upper border line, and perpendicular to the line mn .

Then draw the center line of the balustrade 3 feet from, and parallel to, the attic wall. On this line lay off the angular point 3 feet from the center line mn . Mark the distance of return of the attic wall from the center line mn , which is 6 feet. Join this point to the angular point on the center line of the front cap rail, by a line that will define the center line of the side rail. Draw the edges of the cap rails at a distance of $2\frac{1}{2}$ inches from the center line. Observe that the rails are of the same width as the angle post. Now draw this post, the size on the face lines being $4\frac{1}{2}$ inches on each side of the angle, and the returns at right angles with the rails. Then draw the post at junction with the attic wall, the angle being $3\frac{1}{2}$ inches from it, and the width on the face line of the side being $4\frac{1}{2}$ inches, the return being at right angles with the rail. From the intersection of this return with the inner line of the rail, draw a line at right angles

with the attic wall. Now indicate the position of the balusters under the side rail in dotted lines, as shown. As the balusters are 3 inches square, draw the face lines $1\frac{1}{2}$ inches on each side from the center line of the rail; lay off $1\frac{1}{2}$ inches, which is one-half the thickness of the baluster on each post, and divide this line, which is thus 3 inches longer than the space between posts, into eight equal parts, which will locate the center of each baluster. With the dividers set to $1\frac{1}{2}$ inches, lay off from each center the position of the individual balusters and draw them, the edges being perpendicular to the center line.

Next draw the balustrade of Fig. 2, beginning by projecting the lines of the posts down from Fig. 1. This done, proceed to draw the balustrade on the front of window. Project the lines of the rail and the base from Fig. 4. To draw the ramp of the rail, locate the center of the curve at a distance of 9 inches from the post, and at a distance of 4 inches above the upper edge of the rail. From this center, with a radius of 4 inches, describe the vertical curve of the upper face of the rail; with a radius of 8 inches, describe the curve of the lower face of the rail. Draw a horizontal line from the center, from which the curves are described forward to the post, from which measure down 4 inches, the thickness of the rail, and draw the lower line of the rail. At the intersection of this line with the curve, draw the miter line. Now draw the curved lines defining the members from the horizontal line up to this miter, and from their intersections continue them forward to the post.

Careful observation will show that, as this miter line does not bisect the angle of 90° formed between the upper horizontal line of rail and the tangent line to the curve, it is not a true miter, and that the short section of horizontal rail against the post will vary slightly in outline from that of the other rail; but, as the ramps are worked out of a solid block, the molding is developed to suit the shape at the miter line.

Now draw the rail over the side window, the ramps of which, being projected on a plane that is turned at an angle of 45° from the face line of side window, present a complex

appearance. First draw the horizontal lines of the rail; the main lines of the ramps can be drawn approximately as follows: Project the joint line $1-1'$ and the miter line $2-2'$, from Fig. 2, to $1''-1'''$ and $2''-2'''-2^{iv}$, in Fig. 1. Transfer these lines to each end of the side rail, which will define these joint and miter lines in the position they occupy on the side rail. Now project the joint lines $3-3'-3''$ and $4-4'-4''$, and the miter lines $5-5'-5''$ and $6-6'-6''$, from Fig. 1 down to Fig. 2. The intersection of the line from point 5 with the horizontal relative line on Fig. 2 will give the point where the curve begins, and the line from point 3 will give the point where the curve joins the straight line. The lines from points $5'$ and $3'$ on the center line of the rail will give the points on the center line of the rail in Fig. 2, where the curve begins and ends; similarly, the lines from $5''$ and $3''$ will give the beginning and the end of the curve on the inner edge of the rail. Join the points with an irregular curve, drawing in the lower curve and the intervening members. Locate the ramp next to the angular post in a similar manner. The cap rails being now drawn, finish the caps and bases of the posts and draw in the balusters; begin with those over the front window, lay off $1\frac{1}{2}$ inches (which is one-half of the thickness of the baluster) on the post at the base rail, and divide the line between this point and the center line mn into seven equal parts; the divisional points will be the center of the balusters; with the dividers set to $1\frac{1}{2}$ inches, mark the edges from these centers and draw the vertical lines. Now draw the horizontal lines by projecting them from Fig. 4, and complete the balusters. Draw the balusters over the side window, first drawing the center lines by projecting them from the center of the balusters indicated under the side rail on Fig. 1. Then draw the horizontal lines defining the height of the blocks at top and bottom of the baluster. This done, project the angles of the blocks down from Fig. 1, which gives them the appearance of lapping over one another. Observe, also, that the blocks measure less in width on the face, this being caused by the fact that the face of the object represented is not parallel to the plane on which it is drawn,

this diminution being proportionate to the angle that the object makes with the plane to which it is projected. This applies, however, only to angular objects, or those not circular on the plan. The baluster sections, which are turned, are circular on the plan, and, therefore, do not change in appearance. Having already drawn the center lines for them, draw the horizontal lines across for the molded portions; locate the centers from which the curves are drawn, and complete the balustrade. Observe that the eave mold abuts against the wall post. The height of these lines above the cornice can be obtained from Fig. 6. The intersection can be projected from Fig. 1, but not until the cornice lines have been drawn in position. Proceed to lay down the cornice lines on Fig. 1. From the center line of the rail lay off the cornice projection, which is $13\frac{1}{4}$ inches from, and parallel to, it. The side cornice is also $13\frac{1}{4}$ inches from, and parallel to, the center line of the side rail, and the main cornice is $19\frac{1}{4}$ inches from the line of the attic wall. This line being drawn, draw a line 4 inches from, and parallel to, it, which defines the crown slope of the cornice, which is shown on Fig. 4. The line adjacent to this one is the intersection of the slope of the side of the gutter with the bed. As the sides of the gutter are sloped, the width of the bed, or bottom of the gutter, diminishes, as was explained relative to the gutters on veranda roofs. Locate this line by the dividers applied to scale.

By reference to Fig. 6, which is a section of the main cornice at the eave, it will be seen that the molding that overhangs the gutter projects 6 inches beyond the face line of the wall. On Fig. 1, at a distance of 6 inches from the attic wall (which is on the same line as the face line of the main wall), draw the line of this eave mold, which will intersect with the line of post. This intersection being found, it can be projected down to Fig. 2. The slope line above this intersection on Fig. 2 shows the intersection of the inclined plane of the roof with the face of the post. Now complete Fig. 1. Draw the lines that represent the molded caps; also, draw the line in advance of the rail that shows the edge of

the gutter. The line in advance of the eave mold is the intersection of the slope of the side of gutter with the bed. Draw the miter lines and the hip line shown, which is the junction of the inclined surfaces of the balcony floor. The post in Fig. 4 can now be completed by projections from the post on Fig. 2. Figs. 1, 2, 3, and 4 should now be carefully examined and compared with the engraving, errors corrected, and omissions filled in.

Now draw Fig. 5, which is a transverse section through the head of the first-story bay window, to show the construction of the molded course, the sill on which the frame wall of the second story is erected, the head of the window frame, etc.

Begin by drawing the face line of the wall, projecting down from Fig. 4, as it occupies the same plane. At a distance of 12 inches from the face line, draw the inner line of the brick wall, from which draw the furring and plastering lines, each 1 inch apart, total 14 inches, as shown. Show the stone lintel on the outside, 7 inches thick, the balance being occupied by the brick arch; lay off the thickness of the frame wall, which is 7 inches, 1 inch of which is for the wall sheathing, 5 inches for the stud, and 1 inch for the lath and plaster; draw the top line of stone lintel and brickwork at a distance of $1\frac{1}{8}$ inches from the lower border line and at right angles with the face line of wall; mark the depth of stone lintel 10 inches, and form the reveal 4 inches deep from face line. Observe that the stone at this depth is checked 1 inch deep, to allow the outer lining of window frame to pass up behind it; this forms a **weather check**, as it is called. The soffit, or bottom of the brick relieving arch, behind the stone lintel, is shown with a rise of 1 inch above the springing line at jamb. At a distance of 2 inches below the bed of the lintel, draw the line of head-jamb; the sizes of the parts of the frame are the same as those given for the window frames already drawn. The space between the inner face of window frame and face of plaster is occupied by what is called a **jamb lining**, which is $\frac{1}{2}$ inch above the line of head-jamb. Now draw the inside casing, or trim, which, in this case, has

a cornice supported by molded brackets; draw the sill on top of the brick wall, and show a $\frac{1}{4}$ -inch joint for the mortar bed; draw the molded course, as shown, which projects 6 inches from face of wall. Mark the point where the curved sheathing starts from the straight line, which is $17\frac{3}{4}$ inches above the crown of fillet. Connect these points by an irregular curve. It would be well, however, to mark a point in the center of curve, to insure accuracy. To do this, mark a point on the wall line 9 inches below the highest point of curve, and from this point draw a line at right angles to wall, and find the distance to its intersection with the curve; lay off this distance on the drawing, and mark the point. A line used in this connection is called an *ordinate*, and is of great value in locating any number of points on a curve. At a distance of 3 feet $\frac{1}{2}$ inch above the line of jamb lining, lay off the line of second-floor level and subdivide this distance, as shown, $1\frac{3}{4}$ inches for two thicknesses of floor (the rough one and the finished one), 10 inches for floor joist, $6\frac{1}{8}$ inches for plastering and plaster cornice, and $8\frac{7}{8}$ inches for the wall frieze. Observe that the cornice of trim is carried across the wall, occupies the position of an architrave, and is utilized as a picture molding. Draw in these lines and the moldings and dentils of the cornice. Observe that there is a nailing strip on the lower edge of the joist, to which the furring strip is attached, and that the joist is shown spiked to the stud, and is further supported by a vertical block extending from the under edge down to the sill, which is also spiked to stud.

After completing this figure, proceed to draw Fig. 6, which is a transverse section of the main cornice, etc.; from the center line of the wall *op*, draw the thickness of the main wall, showing the thickness of the sheathing, and of the lath and plaster. Draw the top line of the wall plate at right angles to center line *op*, and at a distance of $1\frac{5}{8}$ inches from the upper border line; the wall plate is constructed with two thicknesses of $2'' \times 5''$ scantling; at a distance of 2 feet $9\frac{1}{2}$ inches from top of wall plate, draw the edge of frieze and its thickness, $1\frac{1}{4}$ inches; from the edge lay off the width of

frieze, $9\frac{1}{2}$ inches, 6 inches to drip of corona, $6\frac{1}{2}$ inches for the corona and covering member, and 3 inches for the slope of the crown. Draw these horizontal lines, and subdivide them for the molded members. Observe that the molds are identical with those drawn in Fig. 4 for cornice of the bay window, which is practically the main cornice with reduced projection. Mark the line of projection 18 inches from face of frieze; at the intersection of this line with the line drawn for the top of covering member of cornice, draw the pitch or slope line of roof. This pitch is given as 10 inches in 1 foot, which means that for each foot of horizontal distance the vertical height will be 10 inches. Draw a horizontal line from top of covering member of cornice, say 3 feet long by scale; the vertical height will then be 30 inches, or 2 feet 6 inches. Draw this line, connect its upper point with the point at top line of cornice, which will give the pitch line of roof; 12 inches is therefore the base of the triangle, 10 inches its vertical height, and the slope or pitch length, the hypotenuse. Now draw the thickness of the roof boarding, 1 inch, and the depth of rafters, 6 inches; these lines when drawn will show the foot-cut on the end of the rafter where it rests on the wall plate. A section of the rafter, called the *toe*, runs over the plate to support the roof boarding, to which the eave mold can be attached. Now draw the boarding of the gutter, as shown. Observe that the corona of the cornice and the gutter are supported by the strip that is run out from the floor joist, to which it is spiked, and which is called the **lookout**, or cantilever, and is usually from $1\frac{1}{2}$ inches to 2 inches thick, to insure strength and thickness for nailing the boarding and blocks to it, which form the cradle of the gutter. Now draw the plaster cornice and complete the figure.

Next draw Figs. 7 and 8, which are details relative to the construction of the front and side verandas, Fig. 7 being a one-half elevation of one of the bays, or divisions, of the front-veranda arcade, and Fig. 8 a transverse section of same. Begin by drawing the center line *qr* of Fig. 8 at a distance of $1\frac{1}{2}$ inches from, and parallel to, the right-hand

border line. Then draw the top line of the water-table, at a distance of $3\frac{3}{4}$ inches from the lower border line, and parallel thereto draw the ground line at a distance of 3 feet below, and parallel to, the top of *W. T.* Subdivide this distance with horizontal lines, beginning at the top, with $7\frac{1}{2}$ inches for base of post, $7\frac{1}{4}$ inches for floor and facia, $17\frac{1}{4}$ inches for height of pier, and 4 inches for ground table, or sill. At a distance of $4\frac{1}{2}$ inches to the left of center line *qr*, draw the outer face line of pier, and $7\frac{1}{2}$ inches to the right of center line draw the inner face line of pier; at a distance of $2\frac{7}{8}$ inches from outer face line of pier, draw the edge line of floor; from the intersection of the edge line with the floor line, draw the upper face of floor to a pitch of $\frac{1}{4}$ inch to 1 foot; draw the thickness of floor, $1\frac{1}{4}$ inches, and draw the lower edge of floor joist which rests on top of pier. Draw the front beam or joist, as shown, 4 inches thick, the back face being on the center line *qr*. Then draw the facia and bed mold, and the screen frame with the strips that keep it in position, the bottom strip being secured to plugs inserted in the stone sill. Having finished the pier and floor construction, draw a line at a distance of 8 feet 9 inches from top of *W. T.*, which will be the height of window lintel marked *W. L.*, with which the top edge of the frieze of arcade is in line. The value of these lines will be fully understood when the elevation of the building is projected in a subsequent plate. Beginning at the top of *W. T.*, subdivide this distance with horizontal lines, $2\frac{1}{4}$ inches for lower block of baluster, $14\frac{1}{4}$ inches for the height of the turning of baluster, 2 inches for upper block of baluster, 2 inches for baluster rail, and 2 inches for cap rail, 4 feet for shaft of post above cap rail, $9\frac{1}{2}$ inches for capital of post; $13\frac{3}{4}$ inches for the rise of arch, $4\frac{3}{4}$ inches to top of astragal member, $6\frac{1}{2}$ inches for the frieze, $8\frac{1}{4}$ inches for the cornice, of which $3\frac{1}{2}$ inches is for the bed mold.

Now draw the face lines of post and frieze, which, being 7 inches, will be $3\frac{1}{2}$ inches on each side of the center line, and draw the projection of cornice 15 inches from the frieze line. From the intersection of this line with the crowning

line of cornice, draw the pitch line of roof (the pitch is 4 inches to 1 foot); then draw the roof boarding, rafter, and ceiling joist, the lower edge of the ceiling joist being 2 feet $5\frac{1}{2}$ inches above the top of capital of post. The ceiling joists on which the rafters rest are supported by a longitudinal beam, which is 4 inches thick by 10 inches high. After drawing the beam, draw the cornice molds. Observe that the arch-key block projects $\frac{1}{2}$ inch below the soffit, or under face of the arch. Draw the molds comprising the capital of the post, the measurements of heights and projections being given on Fig. 7. Then draw the channels cut across the face of the post to define the pedestal block on the post. Draw the section of balustrade composed of the cap rail, baluster, and base rail; the moldings of the baluster can be drawn with the bow-pencil; after which, join the curved members with straight lines as required.

After completing Fig. 8, proceed with Fig. 7. Begin by drawing the center line st at a distance of 1 foot 10 inches from, and parallel to, center line qr , and draw center line uv at a distance of 4 feet $4\frac{3}{8}$ inches from, and parallel to, st . Then draw the thickness of the post, of which uv is the center line. Project all the horizontal lines from the post in Fig. 8, and finish the base pedestal block and the capital of the post. Observe that a flat disk is formed in the face of the pedestal block by cutting a channel, or groove, around same. Now draw the pier, ground table, screen, and floor finish by first projecting the horizontal lines from Fig. 8. From the intersection of the ground line with the center line st , with a radius of 10 feet $9\frac{1}{2}$ inches, describe the soffit line of the arch, making it compound by uniting the small curve, which has a radius of $5\frac{3}{4}$ inches, the center of which is on the line defining the top of capital. Increase the radii $\frac{3}{16}$ inch for the line of fillet, and 1 inch from the first measurement for the edge of angle mold. Now project the horizontal lines of the cornice, etc. from Fig. 8, and draw the **triglyphs**, or grooved tablets, which are shown on the frieze, one being placed over the center of the post, and one over the center of the arch, where the key block of the arch is

treated as supporting it. At the triglyph over the post, the fillet of the astragal is widened, to show extra support for it, the lower end being cut into a series of dovetail guttæ, or drops.

Now draw the balustrade, projecting the members from Fig. 8; lay off the balusters, first marking a point $1\frac{1}{2}$ inches (one-half the width of baluster) on the face of the post. Then divide the distance between this point and the center line pt into eleven equal parts; the points of division will be the center lines of the balusters. Draw these center lines full height of balusters. Then lay off the edges of balusters by the dividers from the center lines; locate the centers of the baluster moldings and describe the curves, after which draw the straight lines between the curves and complete the figure.

Now ink in the figures, draw the dimension lines, write in the dimensions, and letter the figures, titles, and other items of information, where shown on the engraving.

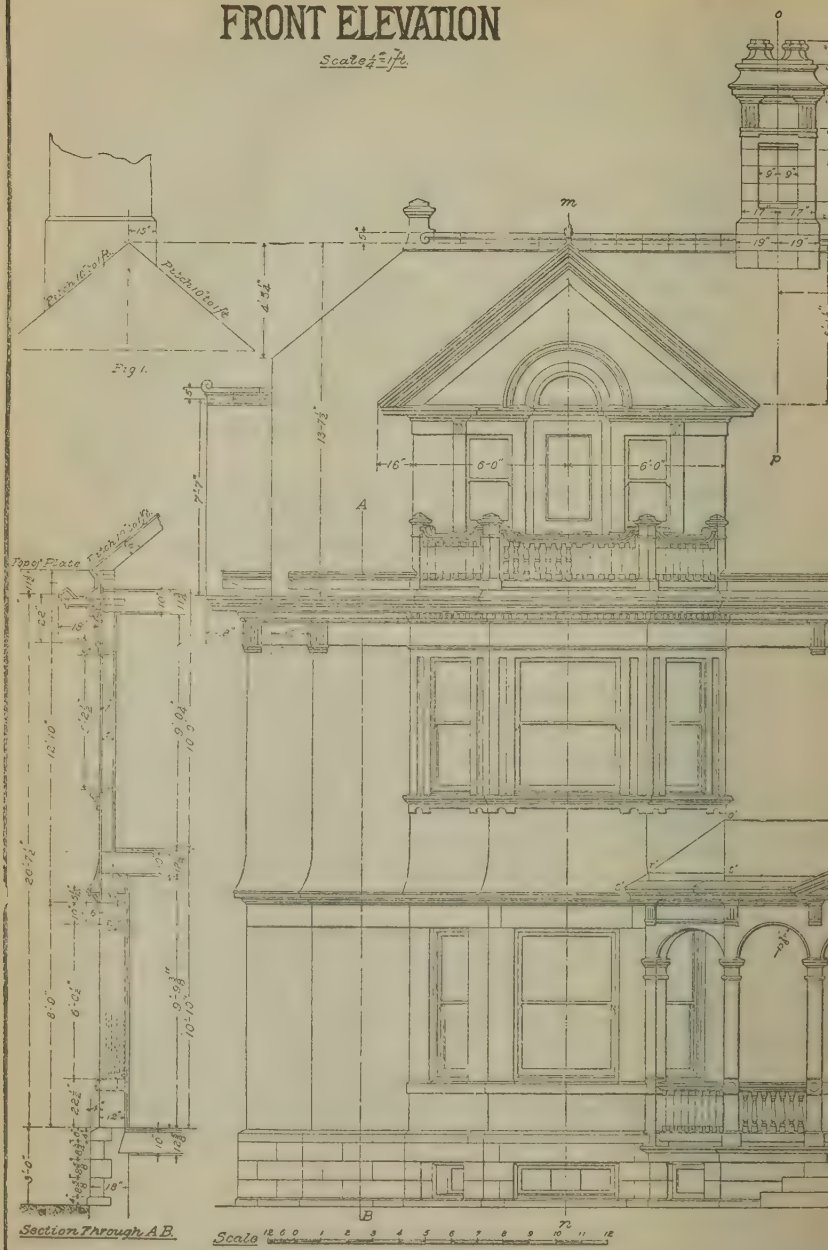
DRAWING PLATE, TITLE: FRONT ELEVATION

16. This plate shows a **vertical section** through AB indicating the mode of constructing the wall of the building, and the leading measurements from which the structure would be erected. This section carefully drawn will give the accurate position of the various horizontal subdivisions of the wall, from which all the horizontal lines on the elevation will be projected. The remainder of the plate is occupied by the **front elevation of the suburban residence**, of which the student has already drawn the first-story plan, the second-story plan, and the plate of details, the figures of which, he will readily observe, are incorporated in the elevation, and will thus be enabled to draw the elevation more intelligently.

The drawing is to be made to a scale of $\frac{1}{4}$ inch = 1 foot. First draw the vertical section, in which the greatest care and precision should be used in order to secure a satisfactory

FRONT ELEVATION

Scale $\frac{1}{4}$ " = 1 ft.



Section Through A.B.

Scale 12' 0" 1 2 3 4 5 6 7 8 9 10 11 12

projection of the elevation. Draw the outer face line of wall above the water-table, at a distance of $\frac{7}{8}$ inch from, and parallel to, the left-hand border line, and draw the ground line at a distance of $\frac{5}{8}$ inch from, and parallel to, the lower border line. Draw the first-floor level at a distance of 3 feet above the ground line, the second-floor level at a distance of 10 feet 10 inches from the first-floor level, and the attic-floor level at a distance of 10 feet above the second-floor level. From each of these floor-level lines draw the lines representing the floor, the depth of joist, and the lath and plaster on the ceiling. Observe that the first and the second floor are double, that is, consist of two thicknesses. Now draw the cellar wall, or, rather, that portion of it which projects above the ground line. This section of the wall is sometimes called *underpinning*, and it is usually faced with dressed stonework, or pressed brick superior to that in the body of the wall. The wall is 18 inches thick, and its face line is 4 inches in front of the face line of the upper wall. The face above the ground line consists of a ground table 4 inches thick, which projects $1\frac{1}{4}$ inches in front of the wall, three ranges of regular coursed ashlar or squared stonework, and a water-table, the upper surface of which is cut with a wash, or inclined surface, to shed the water. Draw these courses and show their width on the bed in the wall. Observe that the courses vary in width alternately (this is what is called the **bond** in masonry), and that the end of the floor joist is cut on an angle. This allows a joist to deflect under a load without straining the wall over it, and in the event of a fire the joists can fall downwards without overturning the wall. In a building of this character, however, these advantages are of no great importance.

Now draw the first-story wall, which is 12 inches thick, and built of brick, up to the top of stone lintel course, which is 8 feet 9 inches above top of water-table. At this level draw the wooden sill, which is 4 inches thick, on which is erected the frame wall of the upper story. Then draw the wall sheathing, which is 1 inch thick, and is brought down to the bed of the sill; the width of studding, which is 5 inches;

and the lath and plaster, 1 inch thick. Draw the top line of plate of frame wall, which is 12 feet 10 inches above the top of lintel course. The plate is composed of two thicknesses of scantling, each of which is 2 inches thick and 5 inches wide. Draw the pitch line of roof from a point that is at the intersection of the projection line of cornice, 18 inches from frieze, and a horizontal line drawn $11\frac{1}{2}$ inches below top of wall plate; parallel with the pitch line of roof draw the roof boarding and the lower edge of rafter, after which draw the outline and construction of the main cornice, taking the measurements from Fig. 6 of plate entitled, Details. Then draw the molded course above the stone lintel course, the particulars of which are shown in Fig. 5 of the same plate.

While this section is on line *AB*, and would therefore not show the position of the window openings, still, for convenience, the necessary data are drawn on this plane, as shown by dotted lines. The height of the window sills from the floor and the distance of the lintels from the ceiling will determine the height of the windows. Having finished the vertical section, proceed to develop the front elevation, which, as in Fig. 2 of the previous plate, is done by projecting those structural lines of the building, which would be seen when viewing it from the front, on a plane assumed to be in advance of the building, this plane being at right angles to its axis, as center line *ab* on the first-story plan, and perpendicular to the floor level, the points for the vertical lines being transferred from the first-story plan and the horizontal lines from points on the vertical section, which has just been drawn. The point of sight is assumed at all times to be at right angles to this plane of representation.

Begin by drawing the center line *ab* (which occupies the same relative position as the center line *ab* on the first-story plan), at a distance of $8\frac{1}{8}$ inches from, and parallel to, the left-hand border line, and draw the ground line at right angles thereto, projected from the ground line of vertical section. Now draw the vertical center line *mn* from the position of the center line of bay window on first-story plan,

and also the center lines qr and st , all of which are to be parallel to center line ab , their correct location to be ascertained from first-story plan. Project all the horizontal lines from the vertical section, drawing them with great care, as a slight deviation will alter the proportions of the molded sections. As the top of the eave molding on the gutter in main cornice is the highest point drawn in the section, only those horizontal lines which are below this can be procured from the section. Commencing at this line, work downwards, drawing fine horizontal lines the full width of the sheet, leaving their terminations to be defined when the vertical lines are projected. The lines of the crowning member of the veranda cornice and the lines of the veranda gutter are not shown on the vertical section, and points for these must be obtained from Fig. 8 of the previous plate. Now project the window lintel, sill, and frame lines, and the top line of water-table from the section; also, the lower line of the cellar-window lintels, which is also the line of the lower edge of floor facia, but do not, as yet, draw any of the joint or wash lines of the ashlar masonry, as they would be likely to cause confusion. On the top line of water-table, which has been projected from the vertical section, locate the points that define the position of the structural lines which the first-story plan presents to this plane.

Working to the left of the center line mn , take the following measurements from the first-story plan, marking them on the elevation as they are taken off: 3 feet to external angle of window, the angle where the side of the bay window intersects the house being 3 feet therefrom; adding this measurement to the first will give $3 + 3 = 6$ feet as the distance from center line mn to the intersection with the house line. The angle of the building is 9 feet 9 inches from center line mn , and the wing wall of dining room advances 2 feet 6 inches beyond this. To the right of center line mn , the distance to external angle of window is 3 feet, and, as above stated, 6 feet to the reentering angle. Now, starting from center line ab , to the left is a distance of 2 feet $6\frac{5}{8}$ inches to the center line of window, and to the right

2 feet $2\frac{1}{2}$ inches to center of the doorway, then a distance of 3 feet $4\frac{3}{4}$ inches to the return angle of brick wall, which gives 5 feet $7\frac{1}{4}$ inches from center line ab ; from this wall, at a distance of 3 feet $4\frac{5}{8}$ inches, is the center line qr of window, already drawn; at a distance of 3 feet $11\frac{7}{8}$ inches is the angle of intersection of the curved wall of the tower with the face line of wall, and which should be 4 feet $1\frac{1}{2}$ inches from the center line st of the tower. From this line to the right, at a distance of 6 feet 6 inches, mark the point that shows its semi-diameter; these points being marked with the needle point on the top line of water-table, commence at the right, at the last point plotted, and work back to the left, checking the measurements by reference to the first-story plan, as upon the accurate location of these points depends the value of the drawing. Having checked in this manner, further check a total measurement of the distance of the point limiting the curved wall from the center line ab , which should be 23 feet $7\frac{1}{4}$ inches, the projection of the curved wall from the straight return wall. Lay off to the left of center line ab a distance of 14 feet $1\frac{3}{4}$ inches to the center of the bay window; this distance, added to the distance of 9 feet 9 inches from center of bay window to angle of parlor wall, gives 23 feet $10\frac{3}{4}$ inches. Now check the total frontage that the building presents to the plane, which should be 50 feet. If all the points have been transferred correctly, draw from them lines perpendicular to the top line of the water-table, continuing them up to the line of the lower edge of the frieze of main cornice.

From the center lines of window openings mark a distance on each side equal to one-half the width of the opening, and draw the lines from the sill to the under edge of stone lintel course. This being done, lay off a point 2 inches from each of these jamb lines just drawn for the width of the window frame, and another one 2 inches from the first for the width of sash to the glass line. This may be done by means of the dividers set to 2 inches. This space can be laid off at all the jamb lines, and then, setting the dividers to 4 inches, the sash line can be marked. Draw all these lines parallel to the jamb lines. The frame width

under the lintel will have been already projected from the vertical section, so draw the sash width 2 inches therefrom. Now draw the sill of window frame and the sill of lower sash. The sill of window frame is 2 inches thick, the upper surface from the outer edge to the outer face line of sash being worked to a pitch of $\frac{1}{2}$ inch. The sill of the sash is $3\frac{1}{2}$ inches deep, which makes a total of 6 inches from top of stone sill to the upper edge of sash sill, or lower rail, as it is sometimes called. Now divide equally the distance between the lower edge of the upper rail of upper sash and the upper edge of the lower rail of lower sash, which will give the center line of the meeting rails. Observe that, while only one rail is seen, there are really two, the meeting rail of the lower sash being situated immediately behind that of the upper sash, which is shown. The stiles of the upper sash are extended below the line of the meeting rail to give additional strength, and molded as shown.

Having finished the windows, which are straight and parallel to the plane of representation, draw the window frames and sash of the side openings of bay window. The walls in which they are placed being turned at an angle from this plane, their actual measurements will not be projected on it. By reference to the first-story plan, it will be seen that, while the measurement of the side of bay window is 4 feet 3 inches, this is reduced to 3 feet, when projected to the line of the front wall of window. Any subdivision on this line will be reduced in proportion. Observe, also, that one of the jambs is turned towards the plane of representation, while the other is turned away from it. In the former case the brick jamb and the jamb of window frame and the sash can be shown, while in the latter case none of these can be shown. Observe that all the lines of window frame are not shown, owing to the small scale, and that the lines of the outer lining of frame and the parting strip are omitted, for a similar reason. The jamb line of window frame is shown, but the $\frac{1}{2}$ -inch projection of the outer lining is omitted. In this manner many of the minute details of construction are not designated on drawings made to this scale, which are called

general drawings, but the most minute must be shown on the larger scale drawings, called *detail* drawings. In order to fully understand these lines and the position that they should occupy on the elevation, make a detail drawing of the plan of the side window to a scale of $\frac{3}{4}$ inch = 1 foot (the position of the frame, with relation to the jamb, can be procured from Fig. 5 of the previous plate), and draw the sash stiles in the frame, as one is shown on Fig. 3 of the same plate. In this case show both sash stiles adjacent to each other. This being done, project the lines forward to the extended line of the front of window. The points on this line can then be measured, with reference to the jamb line, and transferred on the reduced scale to the elevation. This will constitute a practical exercise for the student, and he will have a more intelligent conception of the value of the lines. At the window opening in the curved wall, another exception to the mode of showing the window frame and sash in a straight wall may be noted. As the wall curves from the plane in the same ratio on both sides of the center line, a portion of both jambs will be seen, and seen alike, as shown.

Having finished the first-story windows, draw the entrance doorway. The door frame shows a molded edge, and the jamb stone and lintel are shown with a molded architrave worked on same. The door framing is arranged to show a series of six panels in the lower section, while the lock panel is the full width between the framing. These panels are shown with moldings around the framing; the center of the panels is raised, as indicated by the position of the shade lines. Observe that the framing of the door above the paneling is reduced in width, this being done to lighten the appearance around the glass panel, as explained in Art. 11.

Now draw the windows of the second story. These being in a timber wall, the method of showing the window frame is quite different from that of the first story, as will be more clearly seen by reference to the previous plate. The window frame occupies the full thickness of the wall, and the outside casing has to be of sufficient width to cover the pocket for

the sash weights. A sub-sill is inserted under the regular sill of window frame, extending beyond the face of outside casing. In this case the sill is from 1 inch to $1\frac{1}{4}$ inches thick, and the sub-sill $1\frac{3}{4}$ inches thick. At the bay window, a casing, or apron, is shown under the sub-sill. Observe that the section of the apron under the angle casings is increased in depth. This is to give an appearance of additional support for these casings. The window in the tower not being protected by the main-roof cornice, has the cap, or drip member, to throw the water drip clear of the casing. Draw the triglyphs on the frieze. By referring to the second-story plan, it will be seen that the wall surface adjacent to the center line *qr* recedes 18 inches from the face of the dressing-room wall, which necessitates consideration of the cornice treatment, unless an increased amount of projection is given to the cornice. In cases like this, the usual course is to raise the cornice to suit. In order to retain the general cornice level, however, the wall surface is continued above it, and finished at the intersection of the roof plane with an eave mold.

Now draw the roof lines; as will be seen on the engraving, the ridge line, or intersection of the inclined planes of the main roof, is located at a height of 13 feet $7\frac{1}{2}$ inches above the eave line. At a distance of 4 feet $5\frac{1}{4}$ inches below the ridge, draw the eave line of the truncated section of the roof. The intersection with the ridge will be found to be on a line with the reentering angle of the bay window. Having fixed this point, draw the gable-cornice projection, which is 18 inches from the frieze line. From the point of intersection of this line with the eave line already drawn, draw the slope line of the truncated section to the point on the ridge. Draw the ridge line of the roof over the dining-room extension, which is 7 feet 7 inches above the eave line, and the gable-cornice projection 18 inches from frieze line. Now draw the returns of the cornice molds at the eaves, as shown. Draw the portion of the cornice of the kitchen wing which is seen beyond the wall of tower. By reference to the second-story plan, it will be seen that the center of tower is

5 feet from the outer face line of wall of the stair hall, that the wall of kitchen wing advances 12 inches from same, and that the cornice projects $19\frac{1}{4}$ inches from the face of this wall, which will give a measurement of 7 feet $7\frac{1}{4}$ inches, the distance from center line of tower to the eave line of the kitchen cornice. Now locate the ridge intersection of the roof plane over the kitchen wing. First draw the line of the wall, which is $19\frac{1}{4}$ inches from the point just marked. By reference to the second-story plan, it will be seen that the ridge is 14 feet 3 inches from face of wall. Measure this distance on the eave line of cornice and mark a point, and from this point draw a perpendicular line. Its intersection with the ridge line will be the point desired. Connect this point with the eave line; this will define the roof plane. Draw the stone chimney, first locating the center line op at a distance of 6 feet 2 inches from the center line ab , and drawing a series of horizontal lines above the ridge line from the dimensions given, locating the line of the top of the chimney base $12\frac{1}{2}$ inches above the ridge; then indicate a course of 8 inches, the height of the panel 24 inches, an architrave course of 10 inches, the frieze and bed mold 15 inches, the cap $14\frac{1}{2}$ inches, and the terra-cotta flue caps 11 inches in height. Draw the vertical lines from the dimensions given on each side of the center line, 19 inches for the width of base, 17 inches for the shaft, and 9 inches for the panel. Other dimensions can be obtained by scale measurements. Observe that the flue caps are square on plan at the base, and are drawn into an octagonal form at the top, and that the triglyphs have flutes, or grooves, cut in the face. Having completed the chimney above the ridge line, it will be necessary to find the line where the base intersects the inclined roof plane in its passage through the roof. Draw an outline of the roof planes as shown in Fig. 1, the vertical line defining a plane passing through the ridge. This figure is a view of the roof as seen from the end of the building, looking towards the chimney. As the base is 13 inches to the right of the vertical line, this line when drawn will give the point of intersection with the

roof plane, from which a line can be projected over to the chimney.

Now draw the dormer-window over the bay window. The term **dormer-window** is applied to a window rising from the slope of a roof. Lay off the wall lines 6 feet from, and parallel to, the center lines *mn*, draw the cornice projections 16 inches from the wall surface, and at a distance of 6 feet $1\frac{1}{4}$ inches below the ridge line, draw the eave line; as the ridge line of the dormer-window is the same height as the ridge line of the main roof, connect this point by lines to eave points already found, which will give the inclined planes of the roof, and which should be parallel to the slope line of the truncated section of the main roof. Draw the inclined and horizontal cornice and frieze lines from scale measurements, locate the door and window openings and their casings by similar means, and draw the semicircular door head and architrave casing; after which draw the framing of the door and the window sash and draw the balustrade in front of the dormer-window, taking all the measurements and details from Fig. 2 of the previous plate.

Draw the smaller dormer-window, which is located on the center line *ab*, by first drawing the roof planes. Observe that the eave line is level with that of the large window adjacent, and that its distance from *ab* is $35\frac{1}{4}$ inches. From this point draw the left-hand roof plane parallel to that of the large window, and draw the right-hand plane in a similar manner; from the ridge, measure down 3 feet to the center of the circular opening, and draw the circular lines that represent the sash and framing, securing the dimensions by scale measurements from the engraving. Draw the lines that denote the width of the window, $21\frac{1}{4}$ inches on each side of the center line, after which draw the sill and apron; finish the cornice with the corbel blocks projecting from the face of the window returns or flanks, and the pateras, or saucer-like ornaments, sunk in the face of casing to relieve the wide surface.

Now draw the terra-cotta ridge coping and finials on the main roof; the coping is in 12-inch lengths, the joints of

which are shown, and draw the ridge coping of the roof of dining-room extension and the finials of the roof dormer-windows.

To finish the roof and cornice of the circular tower, begin by drawing the eave line of cornice at a distance of 10 feet 1 inch above the eave line of main cornice; then complete the cornice and frieze by scale measurements from the engraving, and draw the double window on front and that portion of a similar window, which, while facing on the side elevation, by following the curved plan of tower, presents a portion to the front elevation. By drawing the plan of the window in position and projecting the lines forward to the front line of the building, their accurate position on the elevation can be determined.

To draw the curved outline of the roof, first locate the centers from which the curves are struck, from the measurements given, and draw the curves with their respective radii. Having drawn the right-hand curve, locate the centers on the left-hand curve, and complete. The curve, or flare, at the base of the roof is sometimes called the *bell-cast*, from its resemblance to a bell, while the roof proper is called an *ogee* roof from its form.

Draw the finial at the apex of the roof as shown, which consists of an apron, base, shaft, and foliated cap.

Having finished the tower roof, draw the curve that denotes the line of intersection of the roof plane with the circular wall of tower. This is an application of Fig. 4 of plate entitled, Intersections and Developments, *Geometrical Drawing*, and is explained in Art. 43. First draw a semicircular curve with a radius equal to the semi-diameter of the tower, the center being located on the center line st adjacent to the curve and at right angles to its axis $w'x$. Draw a line vu to represent the horizontal plane at the eave line $u'x''$, the point u being at a distance of 5 feet 4 inches from v . From u draw the slope line uw of the roof, the pitch being 10 inches to 1 foot; project u to a point u' on the curved line of the tower, and divide the arc $u'w'$ into five equal parts; transfer these points to the roof line uw by lines drawn

parallel to $w'x$, and again transfer points on the roof line to the line uy , which is perpendicular to vu ; at u'' erect a vertical line $u''y'$, on which lay off spaces equal to those on uy . Now project from the points on the arc vertical lines down to the curved face of the tower. The intersection of these lines with horizontal lines projected from the points on $u''y'$ will give points on the desired curve; draw a line through them by means of an irregular curve, and draw the outline of the eave mold and fascia as shown, which abut against the wall of the tower.

Proceed to draw the veranda by first locating the center lines of the posts, procuring the measurements from the first-story plan, and starting from the center ab on plan and elevation. Draw the lower edge of the floor fascia at a distance of $14\frac{3}{4}$ inches below the top of water-table. Then draw the width of the fascia, the thickness of the floor, and the bed mold, the total width being $7\frac{1}{4}$ inches, as shown on Fig. 8 of the previous plate. Draw the width of the posts, which will be $3\frac{1}{2}$ inches on each side of the center lines already drawn; after which draw the vertical subdivisions of the posts, the frieze, and cornice, procuring the dimensions from Fig. 8 of the previous plate. Draw the returns of the post bases and caps and the arch heads which rest on the post, from the dimensions given. Observe that all the curves start tangent to the caps.

To draw the arches which are set obliquely to the face line of the veranda requires a different method. As their face is turned away from the plane of representation, the lines appear shorter and distorted on the elevation, and a portion of the soffit, or under side of the arch, is brought into view. The method of developing the curved lines will be illustrated on the next plate, so that for the present a method of reproducing the curves on the drawing from the engraving will be employed. Draw a line connecting the caps of the posts at the springing line of the arch to the right of the tower, and draw a center line $1-2$ perpendicular to same. For the curve on the outer face, divide the line $2-3$ into four equal parts, and draw lines from these points parallel to $1-2$. The length

of these lines, or ordinates, as they are called, will define the points on the curve, and they can be procured by scale measurements from the engraving. Join the points by an irregular curve. This will give the curve to the left of center line 1-2; the curve on the outer face to the right of the center line 1-2 will be similar. To draw the curve of the inner face, divide the line 2-4 into four equal parts, and proceed as before. The oblique curve at the junction with bay window should be drawn in a similar manner.

Draw the pediment cornice over the entrance to doorway, and the arch key, the triglyphs, and the cornice and bed-mold returns. The position of cornice returns should be taken from second-story plan; draw the lines that denote the gutter along the eave of the cornice.

Next draw the line that defines the intersection of the veranda-roof plane with the wall surface. That portion of the roof adjacent to the center line qr intersects the wall surface at a height of 3 feet 1 inch above the eave line of cornice. Where the roof abuts against the circular wall of tower, the line of intersection will be curved as shown. Points in this curve can be found by the process used to find the intersection of the main roof with the tower. First, locate the point where the hips of veranda roof meet on the tower wall; draw a line cd at a distance of 5 feet from, and parallel to, the center line st , which is the face line of wall behind the tower. By referring to the second-story plan, it will be seen that the point where the hips meet is 5 inches from the face line towards the center line of tower. Draw this line hi also parallel to st ; draw a horizontal line ef at a distance of 3 feet 1 inch above the eave line of cornice, meeting cd in e ; through e draw rep , meeting hi in p , which is the desired point; from p draw the hip lines pq and pr . To find the curve, draw a line jk at right angles to $w'x$; this will represent the horizontal plane at the eave line of veranda cornice; from j' project a line to j on line jk ; from j draw the slope line of roof jl , which has a pitch of 4 inches in 1 foot; on the base line jk , from the point j , lay off a distance of 23 inches and draw a perpendicular line, passing

through $j'l$ at p' , which is the horizontal distance that the point p on the elevation recedes from the point m on the face of tower at the center line st ; from p' project a line meeting the curved outline of tower at p'' . Divide the arc $p''j'$ into four equal parts and project the points found on the arc down to the slope line $j'l$; from the points on $j'l$ draw lines parallel to jk and intersecting lk , which will give the vertical height from base line jk ; transfer these heights to the center line st , from the point m thereon; from the points marked on st draw horizontal lines to hi ; then, from the points on the arc $j'p''$, draw vertical lines; the intersection of these lines with the horizontal lines will give points on the desired curve; through these points draw the line of intersection by means of an irregular curve. To draw the curve on the left of center line st , transfer the points from the curve just drawn; only a portion of the curve will be required, as nm is shorter than mp .

From m project the line $o'p'$; as m advances the same distance from the wall surface at $q'n$ as the wall surface at $o'p'$ does, the curved line $p'q'$ should be drawn by the same method as mp , since the wall surface at $p'q'$ is a quadrant of a circle having a radius of 18 inches, as seen by reference to second-story plan. The position of the hip lines $o'r'$, $o't'$, and $r's'$ can be determined by also referring to the second-story plan; $o'r'$, while drawn as a straight line, would be very slightly curved in construction, as the roof plane intersects the flare of the wall surface of the bay window.

Draw the balustrade of the veranda, procuring the dimensions from Fig. 8 of the previous plate. Observe that only a few of the balusters are drawn in full; the others are shown with top and bottom blocks and center lines.

Draw the cellar windows, the piers for the support of the veranda posts, the screens between same in position, and the stone steps leading to the veranda floor. The lines for the courses of the masonry can be projected from the vertical section. Lay off the length of the stone blocks by scale measurements from the engraving, after which the drawing should be carefully compared with the original, and any

omission rectified and the lines inked in, the curved lines being drawn first. The lines used for the development of the curved surfaces should be neatly inked in, with broken and dotted lines, as shown. The reference figures and letters may be omitted; but the figure dimensions should all be indicated, as they form important parts of the working drawing.

DRAWING PLATE, TITLE: SECTIONAL ELEVATION

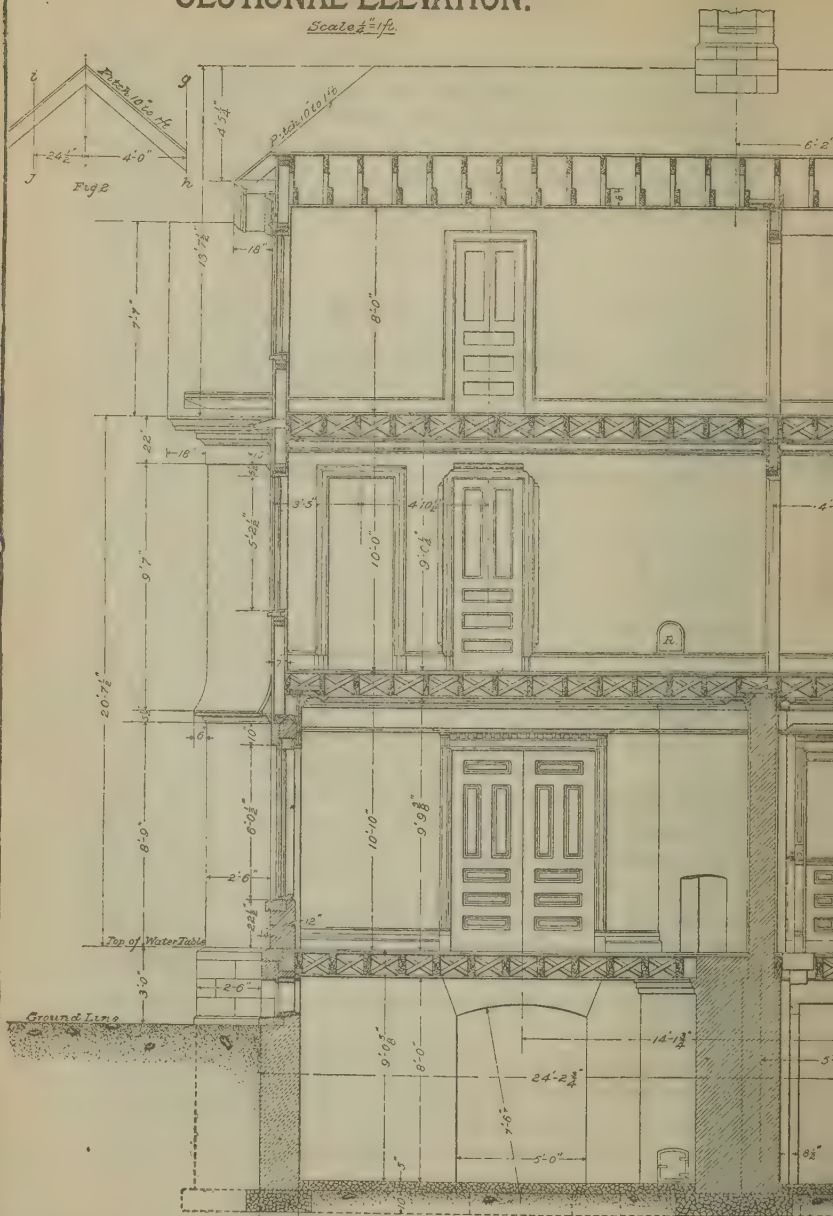
17. Fig. 1 of this plate shows a **sectional elevation**, or longitudinal section on the line $ghijkl$, as marked on the first and second story plans, and presents such a view of the interior as would be seen if the building were cut by a plane following the divisional line $ghijkl$, and the front half of the building removed. Such sections are drawn for the purpose of showing the interior arrangement on the vertical plane, as the plans show the arrangement on a horizontal plane, and while constituting an elevation of the interior, as presented to the plane of the section, it also exposes what may be termed the anatomy of the structure, and shows the relation that exists between the several parts. A better knowledge of the structural value of the lines can therefore be ascertained from such sections than can be secured by the study of either the plan or the elevation.

This section is also to be drawn to a scale of $\frac{1}{4}$ inch = 1 foot. Begin by drawing the center line ab , at a distance of $8\frac{5}{8}$ inches from, and parallel to, the left-hand border line. Then draw the ground line at a distance of $2\frac{1}{4}$ inches from, and parallel to, the lower border line. At a distance of 3 feet from, and parallel to, the ground line, draw the top of water-table, which is also the level of the first floor. This constitutes the base line, from which all vertical lines are measured.

At a distance of 9 feet $\frac{5}{8}$ inch below this line, draw the top line of the cellar floor; then, at a distance of 10 feet 10 inches above top of water-table, draw the top line of second floor. As the distance from second floor to attic

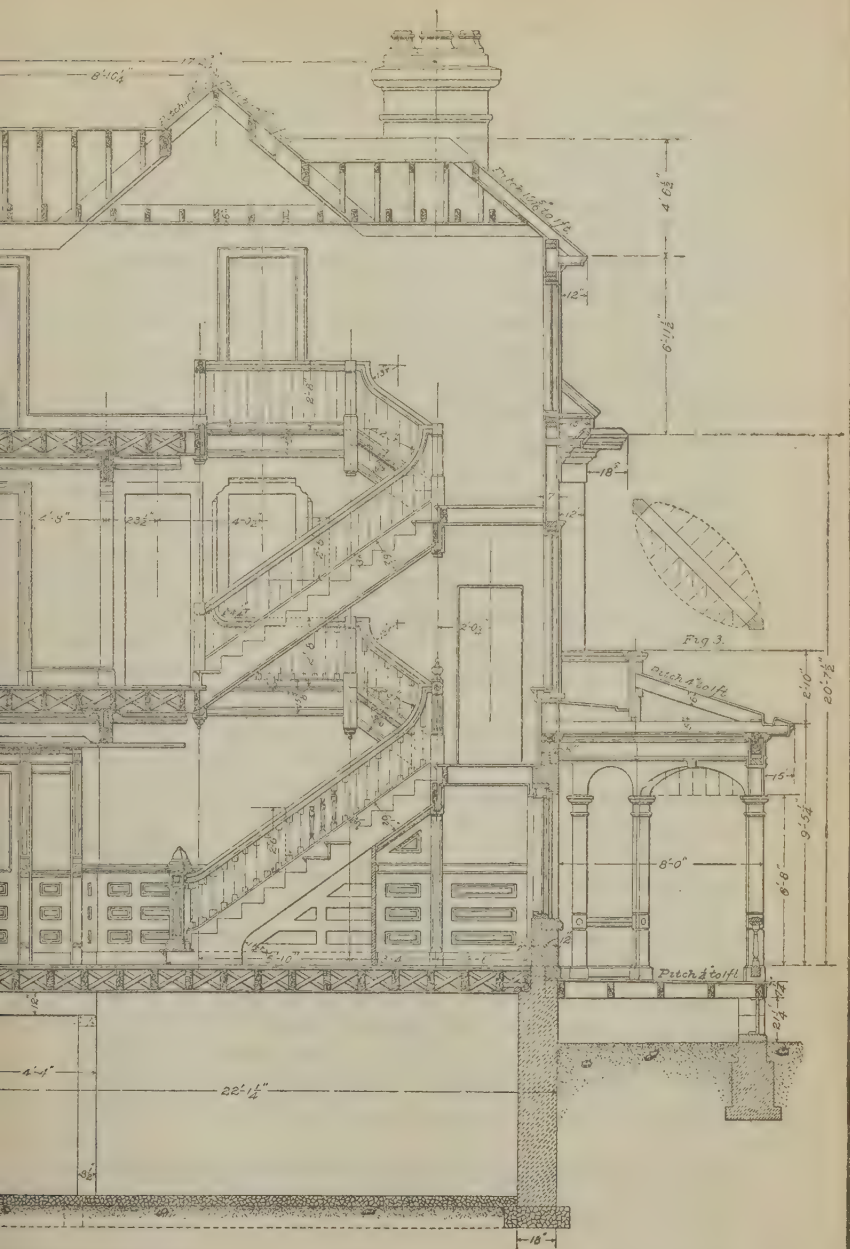
SECTIONAL ELEVATION.

Scale $\frac{1}{2}$ " = 1 ft.



Scale 12 0 1 2 3 4 5 6 7 8 9 10 11 12

Longitudinal Section on Line g



floor is 10 feet, add this to the first measurement, thus making 20 feet 10 inches from the base line to the attic floor. The clear distance between attic floor and ceiling being 8 feet, will give 28 feet 10 inches from base line to attic ceiling. Having located these points, draw through them horizontal lines of indefinite length. Now proceed to develop the section. Begin with the cellar. Draw the flooring and the joists and ceiling over the cellar. The joists are 3 inches thick, and are set at 16 inches between centers. The crossed strips between them are called cross-bridging, and serve the double purpose of keeping the joists from twisting and distributing the weight of the floor when unequally loaded. Before laying off the joists, draw the outer and inner walls of the cellar, with their footings, or base, of concrete. The outer walls are of stone and 18 inches thick; the central wall is of brick, with concrete base, and is 17 inches thick, to which is attached a section of the wall of ash-pit under the parlor fireplace. This gives an additional width of $21\frac{1}{2}$ inches. Since the section plane passes obliquely through the face and return of the wall of ash-pit, it presents this wide surface. As shown, three courses of the brickwork are corbeled out to receive the ends of joists, and an iron door and frame are shown at the base. Draw the arched opening in the wall under the parlor door, the pier supporting the 12-inch beam under the joists of hall, and the angle of the wall under stair-hall partition, which is 4 feet 4 inches from center line *a b*.

The cellar floor is shown constructed with 5 inches of concrete, and the footings of walls, with concrete 10 inches thick.

Now draw the outer walls of the superstructure, above the top of water-table, from dimensions given, and get the subdivisions by scale measurements. Draw the central partition in a similar manner, leaving the work above the attic ceiling to be drawn later. From the second and attic floor lines lay off the ceiling lines. The figured distances will be found by reference to the vertical section on the previous plate.

The drawing will now present six compartments above

the cellar, three of which will be occupied by the stairways and halls, and should be filled in successively.

Draw the stairways first. The stairways have already been represented on plan and will now be developed in elevation. Locate the center lines of newels, and draw them parallel to the center line *ab*; now divide the distance between the top line of first floor and the top line of second floor into eighteen equal parts, and the distance from second floor to attic floor into seventeen equal parts, by fine pencil lines. Mark off on the first-floor line the number and width of steps of the first flight as shown on first-story plan, working from the center line of the platform newel. As the first three steps are curved on plan, take their width on the section line *ij* of first-story plan; from the points marked on floor line draw lines parallel to center line *ab*; the intersection of these vertical lines with the horizontal lines already drawn will give the riser and tread lines of each step and the position of the first platform; project these vertical or riser lines up to the second, third, and fourth flights, excepting, however, the riser lines of the curved steps at start of stairway. These riser and tread lines should now be strengthened by a heavier pencil line and the lighter lines erased. Now draw the upper edge of the inclined stringers, which, as shown, is 3 inches above the tread, measured on a line with the riser. Draw the lower edge parallel with the upper edge, and make the stringers of the widths shown, observing that both the upper and the lower edges at the start are curved. Then draw the upper edge of hand rail, which is on the stair 2 feet 6 inches above the tread, measured on the riser line, and on the landing 2 feet 8 inches above the floor line. Having drawn this line, draw the ramps, or curves, which are introduced for the purpose of raising the hand rail up to the same height as the one on the return flight, and at the landings to the height of the landing rail. The newels on the platforms and landings are then all of the same height. Observe that there is a horizontal knee 6 inches long on the upper edge, between the ramp and the newel.

Now draw the width of the shaft of each newel, which is 5 inches, and the width across the base 6 inches, excepting, however, the start newel, which is 7 inches square above the base; draw the depth of the hand rail, which is 4 inches, with the molded members as shown. This being done, draw a cap 1 inch thick on the upper edge of each stringer, and fill in the balusters, as indicated, subdividing the newels with base, shaft, cap, etc., as shown. On the lower edge of the stringer of the flights, through which the plane of the section passes, will be shown the lath and plaster and the soffit mold, to bind the plastering at its junction with the face stringer, while on the face of the other flights and landings will be shown the face molds, which divide the stringer into architrave, frieze, and base for balustrade. All the newels will have finials, and those disengaged will have pendants, but those on the first flight are only shown, to indicate the general finish.

To draw the start newel, the angles of the newel should be projected forward to section line *ij*, on first-story plan, and transferred to the drawing being made. Complete the other details of the stairways, as shown. Then proceed to fill in the finish shown in first floor, including ceiling beams and cornice, door and window trim, and the wainscoting, which should be drawn to scale measurements, taken from the engravings. Draw the door and corbeled-beam opening in the partitions of second-story hall, with the base and door trim, ceiling beam and cornice, and also the door openings, with base and trim in the attic hall.

Then draw the double door in parlor, with trim, base, and ceiling cornice, and the angular fireplace and chimney, the position of which can be procured by projecting the angle lines forward to the line of section *gh*, on first-story plan, and then transferring them to the drawing.

Draw the door and partition openings, and finish in the rooms over the parlor, as shown. The space marked *R* indicates the position of the hot-air register over the base.

Draw the elevation of the dining-room extension, which is seen beyond the plane of the section on the left, and the

section of the veranda and kitchen extension, which is on the right. The details of the veranda should be procured from Fig. 8 of plate entitled, Constructive Details.

To develop the oblique curve, first draw the plan of the return of the veranda, as shown in Fig. 3, and draw the normal or regular curve adjacent to its face. Divide the diameter into eight equal parts, and draw ordinates at right angles to the springing line of curve. To draw the curve on the inside of veranda, project pencil lines from the points on the springing line of the lower curve down to the springing line of curve on the elevation, and transfer the lengths of the ordinates on the plan down to the elevation; these lengths, measured from the springing line, will give points on the desired curve.

The outer curve on the elevation is drawn in a similar manner, by projections and measurements from the upper curve on the plan.

To show the relative position of the roof lines, rafters, and ceiling joists to the line of section, begin by locating and drawing the main ridge line, which is 13 feet $7\frac{1}{2}$ inches above the eave line of the cornice; then make a diagram like Fig. 2, showing the rafters and boarding, the upper surface of which is the roof plane; the vertical line passing through the ridge represents the ridge plane. On each side of this plane draw the position of the section planes represented by lines gh and ij . By reference to the second-story plan, it will be seen that gh is 4 feet to the right of the ridge line, while ij is $24\frac{1}{2}$ inches to the left of the ridge line. This accounts for the difference in the position of the rafters on each side of center line ab . From Fig. 2, project the line at the intersection of the cutting plane gh with the roof plane, which is the upper edge of the roof boarding; also, the line of the toe of the rafters; then draw the upper edge line of the ceiling joists, and from the inner wall line mark off the rafters 16 inches between centers. To do this, draw the first rafter in position at the wall; then set the dividers to 16 inches, and, starting from the center line of the first rafter, mark the points on the boarding line up to the center line ab ;

then, from these points as centers, with a radius of 1 inch, describe light pencil circles, from which draw the faces of the rafters; draw the legs of rafters down to the ceiling line, and from the right face, with the bow-pencil set to 2 inches, mark the thickness of each ceiling joist forward to the center line *ab*.

From *ij*, on Fig. 2, project the rafter lines as far as the valley rafter, and draw the valley rafter in position, as shown; it supports the short, or jack, rafters. At a distance of 8 feet 10½ inches from center line *ab*, the section plane cuts the ridge of the kitchen extension, and to the right of the ridge it cuts the valley rafters of the roof of dormer-window, over the stair hall. Observe that a portion of the ceiling in the stair hall has to follow the inclination of the rafters, and is known as a *canted* ceiling.

Draw the chimney by scale measurements from the engraving and complete the drawing, after which it should be carefully inked in, and the walls and cross-sections of the timbers neatly sectioned, as shown, and the dimension lines drawn and lettered.

TRACINGS

18. In regular office practice, it is necessary to have more than one copy of a drawing. It would be very expensive to make a finished drawing every time an extra copy was wanted, and, to avoid this, tracings and blueprints are made. As many blueprint copies can be made as are desired from a single tracing. A complete pencil drawing is first made; then, instead of inking in the drawing as heretofore, a piece of tracing paper or tracing cloth, of the same size as the pencil drawing, is fastened to the board over the original drawing. The tracing paper or cloth being transparent, the lines of the drawing can be readily seen through it, and the drawing is inked in on the tracing paper or cloth in the same manner as if inking in a finished drawing.

Tracing paper is but little used in this country. It is easily torn, and cannot be preserved as well as the tracing

cloth. The two sides of the tracing cloth are known as the glazed side and the dull side. The glazed side is coated with a preparation of gelatine that gives it a very smooth, glossy surface; the dull side has very much the appearance of a piece of ordinary linen cloth. Either side may be used to draw upon, but when the glazed side is used, care must be taken to remove all dirt and grease. This can be done by sifting powdered chalk upon the tracing cloth and then rubbing it over the entire surface with a soft rag. It is not necessary to use chalk when the dull side is to be drawn upon, but it improves the surface to do so, and causes it to take ink more readily. The finished drawing looks better and will not soil so easily if traced on the glazed side, and it is easier to erase a line drawn on this side. Pencil lines can be drawn on the dull side, and if it is desired to photograph the drawing, it is better to draw on the dull side. The draftsman uses either side, according to the work he is doing, and to suit his individual taste; but if the glazed side is used, *it must be chalked*. The tracings are drawn in the same manner as the finished drawings, the center lines, section lines, etc. being drawn exactly as previously described.

After having drawn the last plate, the student should make tracings of the plates entitled, First-Story Plan, and Front Elevation, which should be finished and lettered exactly like the paper drawing.

BLUEPRINTING

19. Blueprinting is the name of a process by which any number of copies may be obtained from a single tracing. It is based upon the properties that certain chemicals possess, of changing color on exposure to the light; and its operation consists of subjecting to strong sunlight a sheet of prepared paper, which is covered by the tracing and held in close contact by means of a sheet of heavy glass. The light passing through the transparent tracing causes the paper to turn blue over all its surface, except where protected by the

opaque lines of the drawing, and thereby produces a print that duplicates the original drawing so far as lines and measurements are concerned, but in white lines on a blue ground.

Although it is usually much more economical to purchase blueprint paper ready for use, the ingredients are very simple, and in an emergency the paper may be prepared as follows: In a dark-colored or opaque bottle, dissolve 2 ounces of citrate of iron and ammonia in 8 ounces of water; and in a similar bottle dissolve $1\frac{1}{4}$ ounces of ferricyanide of potash in 8 ounces of water. These solutions should be mixed in equal portions immediately before use, as they deteriorate with age when mixed.

To sensitize the paper, a small quantity of the mixed solutions is poured upon the center of a sheet, and then, by means of a camel's-hair brush or tuft of cotton, it is spread evenly over the entire surface, and any surplus carefully removed. The paper is then hung up to dry, after which it is ready for use. All this must be done in a room lighted with gas, lamp, or weak yellow daylight, and the prepared paper must be kept in a cool, dry, dark drawer or closet, or it will lose its sensitiveness. In any case it does not keep well for any great length of time, and for this reason it is not desirable to prepare more than is needed for immediate use.

The paper used should possess a hard, close-grained surface, and should be well sized. Otherwise it will be necessary to mix about $\frac{1}{2}$ ounce of gum arabic with each of the stock solutions, to prevent the sensitizing liquid from sinking into the pores of the paper and thereby becoming difficult to wash out after the print is made.

Figs. 6 and 7 of the text are two views of a printing frame that is well adapted to printing blueprints not over 17 in. $\times$ 21 in. The frame is placed face downwards, and the back *A* is removed by unhooking the brass spring clips *B, B*, and lifting it out. The tracing is laid upon the glass *C*, with the *inked* side downwards, touching the glass. A sheet of the prepared paper, perfectly dry, is laid upon the tracing with the yellow (sensitized) side against the

tracing. The paper and tracing are smoothed out so as to lie perfectly flat upon the glass, the cover *A* is placed back into its former position, and the brass spring clips *B, B* are pressed under the plates *D, D*, so that the back cannot fall out. All this is done in a subdued light. The frame is now placed where the sun can shine upon it, and adjusted as shown in Fig. 7, so that the sun's rays will fall upon it as nearly at right angles as possible. According to the condi-

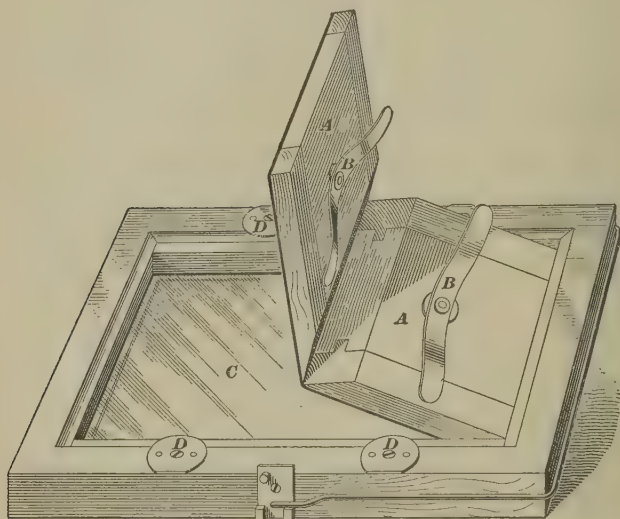


FIG. 6

tion of the weather, whether clear or cloudy, and the time of the year, the print should be exposed from 5 to 20 minutes. A tray or sink somewhat larger than the print should be provided, and filled to a depth of about 2 inches with water. The print having been exposed the proper length of time, the frame is carried into a subdued light, where the cover is removed, and the print taken out and placed in the water, with the yellow side down, and there left to soak while the next print is adjusted in the frame. The first print having been washed about ten minutes, it should be

lifted out by two of its opposite corners and rinsed thoroughly; then it should be hung up till dry. Should any dark-purple or bronze-colored spots appear on the print, after it is dry, they indicate that there was not sufficient washing. If these spots are thoroughly washed before the print is dried, they will disappear. It is best to judge of the proper time of exposure to the light by the color of the strip of print projecting beyond the edge of the tracing. To

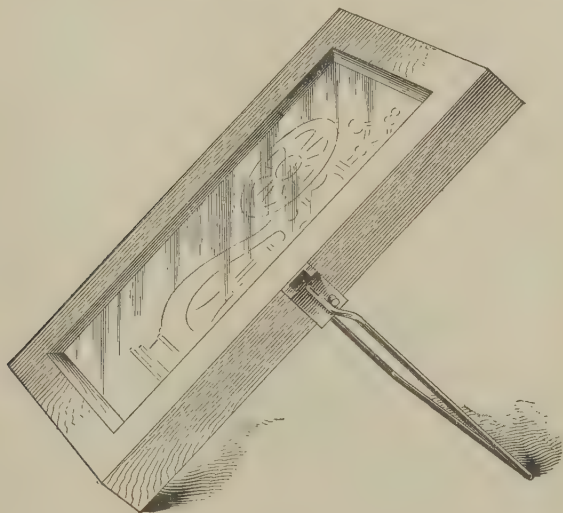


FIG. 7

obtain the exact shade of the projecting edge, take a strip of paper about 12 inches or 14 inches long and 3 inches or 4 inches wide. Divide it into about twelve equal parts by lead-pencil marks, and number each part with the lead pencil 1, 2, 3, etc. Sensitize this side of the paper, and, after it has been properly dried, place it in the print frame with the sensitized side and the marks and figures against the glass. Expose the whole strip to the light for one minute; then cover the part of the strip marked 1 with a thin board or anything that will prevent the light from striking the

part covered. At the end of the second minute cover parts 2 and 1; at the end of the third minute, parts 3, 2, and 1,

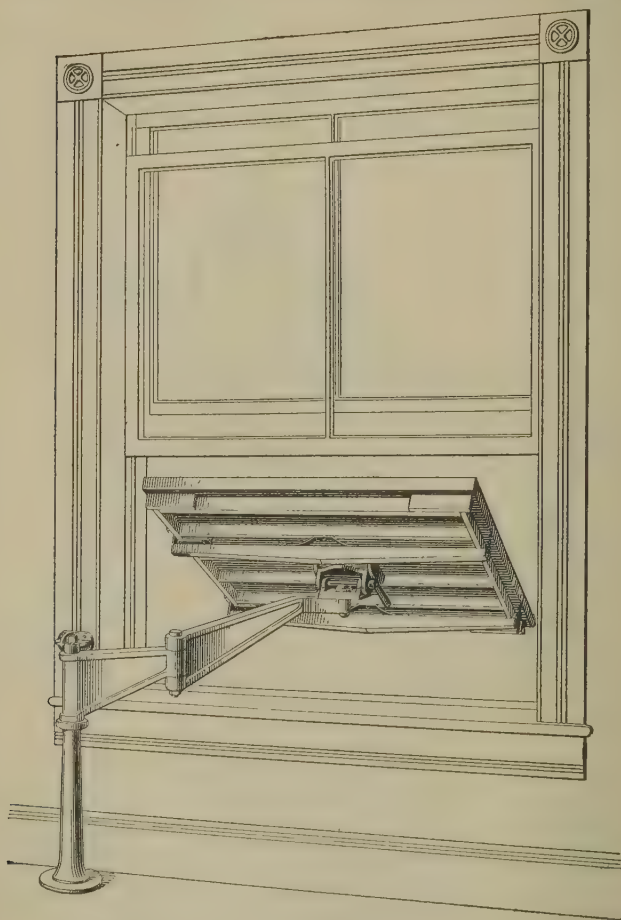


FIG. 8

etc. When twelve minutes are up, part 1 will have been exposed one minute; part 2, two minutes, etc., part 12 having been exposed twelve minutes. Remove the frame to

the dark room, and cut the strip so that it will be divided into two strips of the same length and half the width. Wash one of the strips as before described, and when it has dried, select that shade of blue which suits; notice the number of the part chosen, and it will be the length of time that the print was exposed. Examine carefully the corresponding number on the other strip, and the correct color of the projecting edge of the print beyond the tracing is determined. All prints should be exposed until this color is reached, no matter how long or how short the time may be; then they should be immediately taken out and washed.

Fig. 8 of the text shows a patented frame that can be swung to the outside of the window and adjusted to any angle. When not in use, it can be folded up against the wall, and occupies but a little space. It is made in different sizes, from 16 in. $\times$ 24 in. to 48 in. $\times$ 72 in. It is one of the best frames in the market, and is placed in such a position relative to the window that the window sash can be lowered to the top of the main arm, to keep out the cold during the winter.

DRAFTING-ROOM PRACTICE

20. The practice in the architectural drafting room is as varied as the individuality of the architect. Many architects, in order to practice economical administration in their offices, make as few drawings as possible, and those that they do make are exceedingly meager in detail and dimensions. On the other hand, the conscientious architect, who bears in mind his client's welfare, furnishes all the necessary drawings required to show every detail of construction. He exercises care in dimensioning his drawings, so that there can be no possible misunderstanding of his intentions by the contractor.

It is the architect of the latter class we desire our students to emulate, and the drawing plates in the course have been laid out so as to inculcate precision and accuracy. They are completely dimensioned in every detail, and though the

student may in practical work learn short-cut methods, he must first understand thoroughly that a drawing to be of use must contain all of the information necessary and required by the contractor in the erection of the structure, the drawings, of course, being supplemented by the stipulations in the specifications.

The work of the practicing architect includes the making of preliminary sketches or studies; working drawings such as plans, elevations, and sections, drawn to a scale of $\frac{1}{8}$ inch or $\frac{1}{4}$ inch to the foot; and detail drawings full size or to a scale of $\frac{3}{4}$ inch or $1\frac{1}{2}$ inches to the foot. Distinct from the work of drafting is the writing of the specifications, the conduct of the business between the owner and the contractor, and the superintendence of the work under construction.

The preliminary drawings or sketches are usually made roughly in pencil, but with an artistic touch, and are often tinted to show the color scheme of the interior and exterior of the building. The working drawings are carefully studied and laid out to meet the requirements of the client. In making these drawings the general construction is decided upon, the walls and foundations proportioned, and the elevations carefully designed. The detail drawings are employed to show the special construction of the steel or wood framing, interior trim and details, or exterior masonry or carved stonework. Besides these the architect often finds it necessary to furnish full-size details on manila paper of window boxes, door frames, and such work as carved-stone or terracotta details.

As much of the time the successful architect is devoted to the business part of his work and exercising a supervision over the work in progress in his office, he usually employs a chief draftsman or designer who is a competent architect. Subordinate to this person there may be several draftsmen and one or two students. The larger offices in the great cities have a more complex system, from the fact that they employ from fifty to one hundred people. Where the organization is of this scope, it is usual to subdivide the work and place one building in the hands of a competent designer with a

couple of assistants, it being their duty to devote their sole energies and time to the one structure. This person is directly under the control of the chief of the office. Connected with these large offices are a number of building superintendents whose duties are to inspect the work under way on the various buildings. One inspector would usually be assigned to each large piece of work.

The systematic practicing architect has a uniform style of lettering for all of his drawings, and they are usually titled at the lower right-hand corner. At this position is either printed or stamped the architect's name and the words title, scale, job number, contractor, etc., and after each the necessary information is printed by the draftsman. The drawings are all filed in drawers, either by numbers or alphabetically, so that a particular drawing can be obtained with a minimum loss of time. Where the drawings are numerous it is necessary to have a card index; that is, a system by which the records of the drawings are made upon cards which are systematically filed and cross-indexed. By reference to the cards the number of the drawing is obtained and its place in the files known immediately.

Many architects engage in consultation with a structural engineer when the work requires an expert in steelwork, heavy construction or foundation work. Such services are usually paid for at a stipulated sum agreed upon, which may either be a percentage of the architect's fee or a fixed amount.

It is not unusual for architects to engage in competition for large work. Either in answer to an advertisement or by request, they prepare plans, elevations, and sometimes perspectives of the proposed building. These are submitted on or before a certain date to a judge or committee which adjudicates on the merits of the designs. The judge or committee selects the one which appears the most suitable, and the successful architect is either rewarded by receiving the commission for the execution of the work, or is paid a substantial premium. In order to encourage competition, it is usual in large works to offer three or four prizes, the lowest

of which will at least pay a portion of the expenses the architect has incurred in preparing the drawings. After the selection the drawings are returned to the unsuccessful competitors. It is usual that competitive drawings are required to be submitted in a uniform style of rendering. The usual requirements are that the drawings be of a particular size, that the building shall not exceed in cost a stipulated sum, and that plans, elevations, and perspectives be furnished, consisting of line drawings in ink on white paper and that the windows shall not be blackened, and no wash, color, or shade lines shall be used.

ESTIMATING AND CALCULATING QUANTITIES.

INTRODUCTION.

1. Scope of Subject.—The art of estimating is very important both to the architect and to the builder; to the latter, in that he must employ some systematic method of estimating in order to carry on his business successfully, and to the former for the reason that he should at all times be able to estimate the cost of the buildings which he designs.

The science—for such it is—of fixing prices on a piece of work in any branch of the building trades, must be based on an extended experience. Any one can, with a little practice, learn to take off the quantities of materials, but when it comes to determining the rates, only a person of large and varied knowledge of building and costs of various details can accurately estimate the time and labor required to complete the work. It is the aim of this section to put the student on the proper course to pursue in order to become a practical estimator. For this purpose, a number of detailed estimates, and a complete example in estimating, are given as guides; it should be remembered, however, that as the prices of materials and labor vary from those assumed, so will the estimates vary. The estimates given herein are, in general, net figures, and do not include any contractor's profit.

2. Qualifications of the Estimator.—In this country there are no standard or definite rules on estimating which

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hold good in every section, the builders of each locality having their own ideas and customs in regard to the subject; this fact, together with the difference in the cost of labor in various parts of the country and the fluctuations in the market price of materials, requires, as before remarked, that the really clever estimator be a man of long and varied experience in the business. There are, however, certain practical rules and suggestions that will materially assist in taking off the quantities, and in valuing the labor required for any building operation. These will be taken up and considered in detail in this section.

3. Important Factors.—The prime considerations in making an estimate are time and accuracy; to these ends, the estimator must systematize his efforts and endeavor to do a maximum amount of work in a minimum amount of time; but not at the expense of accuracy, which is the most important factor, and which is only insured when the figures are carefully checked. The estimator should, therefore, while avoiding too great refinements in calculation, aim at correctness rather than speed in doing the work. Very frequently do the effects of haste and inaccuracy in estimating the cost of a structure become evident when it is too late to remedy the errors, resulting sometimes in the financial ruin of the builder who trusts too implicitly in the estimator's figures.

A record should be kept of all estimates made, as this kind of information is most valuable, and establishes a precedent upon which to base subsequent estimates, as well as a check on the work at hand.

PRINCIPLES OF ESTIMATING.

OUTLINE OF THE WORK.

4. Schedule.—The drawings and specifications for a structure are the guides which the estimator must follow in making his computations. All measurements necessary for calculating the quantity of the materials required are obtained from the drawings; and all information in regard to the

character of the workmanship and the quality of materials to be used is furnished by the specifications.

In compiling a schedule, there are three stages to the operation: *first*, taking the dimensions for each of the various classes of work; *second*, computing and collecting the quantities; and *third*, estimating the cost. In carrying out the first of these steps, each of its subdivisions should be considered in the order in which the work will be executed in the building; this order is about as follows:

- | | | |
|----------------|------------------------------|----------------------------------|
| 1. Excavation. | 5. Roofing. | 9. Heating and
Ventilation. |
| 2. Stonework. | 6. Plastering. | 10. Plumbing and
Gas-Fitting. |
| 3. Brickwork. | 7. Joinery. | 11. Painting and
Papering. |
| 4. Carpentry. | 8. Hardware and
Ironwork. | 12. Glazing. |

The third step, estimating the cost, may be subdivided into cost of labor and cost of material. The latter can be definitely fixed by an examination of lists giving current prices of materials; while the former must be based on a fixed rate of wages per day for the various classes of workmen.

The second and third branches of the work, being closely connected with the first, will be partially considered in connection with it, and, later, in detail in the complete example on estimating.

APPROXIMATE ESTIMATING.

5. Preliminary Estimate.—In order to make a preliminary estimate, before the plans of a structure are drawn, but after the general dimensions of the proposed building have been determined, architects and builders sometimes employ a method of approximate estimating, by which the cost is figured at so much per cubic foot of the building, the

rate varying according to its character and the finish required. The method is also considerably used by insurance companies in fixing the amount to be placed on a building. It must be borne in mind by the student that this method gives the approximate cost only, and should never be used in figuring the contract price of a building. This estimate, however, may be used to advantage in checking the accurate estimate, with which it will frequently be found to agree remarkably well.

The following table shows the approximate cost per cubic foot of various kinds of structures. In computing the contents of a building, there is no uniformity in practice, but no great error will be made in figuring the solid contents from floor of cellar to ridge of roof.

COST OF BUILDINGS PER CUBIC FOOT.

Class of Building.	Cost. Cents per Cubic Foot.
Small frame buildings, costing from \$800 to \$1,500	8 to 9
Frame houses, 8 to 12 rooms, costing from \$1,500 to \$10,000.....	9 to 11
Brick houses, 8 to 10 rooms.....	10 to 14
Highly finished city dwellings (brick or stone).....	17 to 20
Schoolhouses (brick).....	9 to 11
Churches (stone).....	20 to 25
Office buildings (well finished).....	30 to 40
Hospitals, libraries, and hotels.....	32 to 44

ESTIMATING SCHEDULE.

6. Accurate Estimate.—There are so many items to be considered in a careful estimate, that the estimator should have a list of those coming under each of the main headings

enumerated in the preceding paragraphs, and in compiling a schedule he should follow this order. The subjoined list, which is arranged to assist in making an estimate on a dwelling house, will serve as an example of the general method which should be adopted.

EXCAVATION.

Cellar	Catch basins
Areas	Pipe trenches
Piers	Grading
Privy vaults	Filling
Footings	Labor
Cesspool	

STONEMWORK.

Lime	Area walls
Cement	Chimneys
Sand	Footings
Mortar	Cut or dressed stonework
Concrete	Carved stonework
Foundation walls	Anchors and bolts
Partition walls	Labor
Piers	

BRICKWORK.

Lime	Cesspools
Cement	Range setting
Sand	Furnace setting
Mortar	Footings
Foundation walls	Chimneys
Exterior walls	Trimmer arches
Partition walls	Brick hearths
Area walls	Labor

CARPENTRY.**Framing.**

Girders in cellar	Headers
Sills	Trimmers
Cross-sills	Common rafters
Posts	Hip rafters
Beams	Valley rafters
Girts	Purlins
Studs	Furring
Plates	Ridge pole
Deck plates	Collar beams
Tower plates	Lintels
Braces	Framing piers
Joists, basement	Outlookers
Joists, first story	Carrying beams
Joists, second story	Ironwork
Joists, third story	Rods and bolts
Joists, attic story	Nails and spikes
Ceiling beams	Labor

Covering.

Sheathing lumber	Flooring
Sheathing paper	Corner boards
Base	Casings
Siding	Cornice
Shingles	Labor

ROOFING.

Tin	Flashings
Shingle	Gutter linings
Slate	Solder
Tile	Cresting
Paper or felt	Finials

Roofing—Continued.

Painting tin	Conductor hooks and fastenings, nails and hooks
Hanging gutters	
Conductor pipes	Cast shoes or boots
Conductor heads	Labor

PLASTERING.

Lath	One-coat work
Lime	Two-coat work
Sand	Three-coat work
Hair	Stucco cornices
Plaster of Paris	Stucco arches
Plastering mortar	Stucco centers
Deafening	Nails
Back plastering	Labor

JOINERY.*Inside and Outside Finish.*

Window frames	Wainscoting
Door frames	Moldings
Sashes	Planed lumber
Doors	Posts
Base	Columns
Architraves	Balusters
Corner and plinth blocks	Hand railing
Outside and inside blinds	Nails and screws
Brackets	Labor

Stairs.

Rough lumber	Hand railing
Treads and risers	Balusters
Strings	Brackets
Spandrels	Bolts
Moldings	Nails and screws
Newels	Labor

HARDWARE.

Mortise locks	Sash lifts
Rim locks	Sash cord
Padlocks	Transom lifters
Butts (various sizes)	Cupboard catches
Wrought butts	Hooks and eyes
Strap hinges	Drawer pulls
Blind hinges	Mortise bolts
Sash fasteners	Door stops
Sash weights	Door hangers
Shutter bars	Axle pulleys

HEATING AND VENTILATING SYSTEM.**Hot-Air Heating.**

Furnace	Registers
Cold-air ducts and slide dampers	Sheet-tin and asbestos fire protection
Hot-air pipes, elbows, and dampers	Smoke pipe
Register boxes	Labor

Steam Heating.

Boiler	Air vents
Regulating and safety appliances	Floor and ceiling plates
Smoke pipe	Galvanized sheet-iron casings for indirect stacks
Steam pipes	Sheet-iron indirect flues, screens, and dampers
Return pipes	Indirect registers and boxes
Fittings	Japanning and bronzing
Hangers	Pipe coverings
Indirect, direct-indirect, and direct radiators	Labor
Radiator valves	

Hot-Water Heating.

Heater	Radiators, pipes, fittings,
Automatic damper regulator	etc., same as for steam
Smoke pipe	heating
Expansion tanks	Labor

PLUMBING AND GAS-FITTING.**Plumbing Fixtures.**

Kitchen range, with water-	Kitchen sinks
back	Pantry sinks
Plunge baths	Slop sinks
Shower baths	Laundry tubs
Foot baths	Safes
Sitz baths	Hot and cold water faucets
Wash basins	for fixtures
Water closets	Labor
Urinals	

Water Supply.*City Supply.*

Permits	Outside piping
Corporation connections	Lawn and garden hydrants
Excavation	Fittings, etc.
Extra-heavy lead, iron, or	Wrought-iron pipe fittings
brass service pipe	Brass-pipe fittings
Curb cock and box	Lead-pipe fittings
Stop and waste	Solder nipples

Well Supply.

Storage cisterns	Stop-cocks
Cistern filters	Pipe straps
Pumps	Metal tacks
Supply tanks	Kitchen boiler and stand
	Wiping solder
	Labor

House Drainage.

Permits	Vitrified sewer pipe and fit
Sewer connections	tings
Excavation	Earthenware traps

House Drainage—Continued.

Portland cement	Brass traps
Unglazed drain pipe	Fixture connections (brass)
Cast-iron soil pipe and fittings	Wrought-iron, galvanized, or asphalt-coated drain, soil, and vent pipes and fittings
Lead and oakum	
Cast-iron traps	
Handholes and cleanouts	Fresh-air inlets, vent caps
Lead bends, brass ferrules	Vent-pipe flashings
Lead soil, waste, and vent pipes	Wall hooks, straps, bands, and hangers
Lead traps	Labor

Gas-Fitting.

Permit	Chandeliers
Tapping main	Pendants
Excavation	Wall brackets
Meters	Pillar lights
Stop-cocks	Globes, shades, and fire guards
Drip cups	
Piping	Gas stoves and ranges
Straps and hangers	Gas-heater connections
Fittings	Labor
Pressure regulators	

PAINTING AND PAPERING.**Painting.**

Body of house	Sash
Trimmings	Shelving
Blinds	Mantels
Roof	Oiling
Porches	Polishing
Inside work	Varnishing
Floors	Fences
Ceilings	Outbuildings
Walls	Labor

Papering.

Paper	Lining paper
Borders	Labor

GLAZING.

Sheet glass (single or double thick)	Ribbed glass
Plate glass	Frosted glass
Leaded glass (stained or clear)	Glazier's points
	Putty
	Labor

EXCAVATION.

7. Matters To Be Considered. Excavation is generally measured by the cubic yard, although, in a few localities, measurement by the perch is still in use. If the latter method is adopted, it should be stated just what is meant by a perch, as this varies considerably in different parts of the country.

Before fixing the price for excavation, it is advisable to investigate the character of the soil, by making boring tests. Where there is rock excavation which requires to be blasted, a special price should be given in the estimate. If the ground is wet, rendering pumping necessary, provision should be made for the cost of the extra labor needed. The disposition to be made of the excavated material should also be considered, as, if it must be hauled a long distance, the cost will be much greater than if the soil may be *wasted* near by. To aid in estimating the actual cost, it is convenient and approximately correct to consider 1 cubic yard of ordinary earth as a load for an ordinary two-horse wagon.

In making calculations of the amount of material to be removed, care must be taken to note the existing levels of the ground and those required by the drawings. The excavation should be figured (and made) at least 1 foot greater than the size of the foundation, so as to provide room for setting the masonry, pointing, etc. . -

Excavation for pipes, drains, etc. should be at least 9 inches wider than the diameter of the pipe to be laid therein. If the soil in which the excavation is made is of a

loose and sandy nature, likely to crumble and slide, a slope, say of 3 inches horizontal to 1 foot vertical, should be allowed on both sides of the trenches. If the latter are of considerable depth, it is sometimes necessary to curb or shore up the sides, in which case an allowance should be made in the estimate for the lumber required.

If piles are required, figure them at so much per lineal foot, driven.

CALCULATION OF EXCAVATION.

8. Volume.—The ordinary rules of mensuration are all that are needed to compute the volume of any excavation. The work is very simple when the area to be removed is

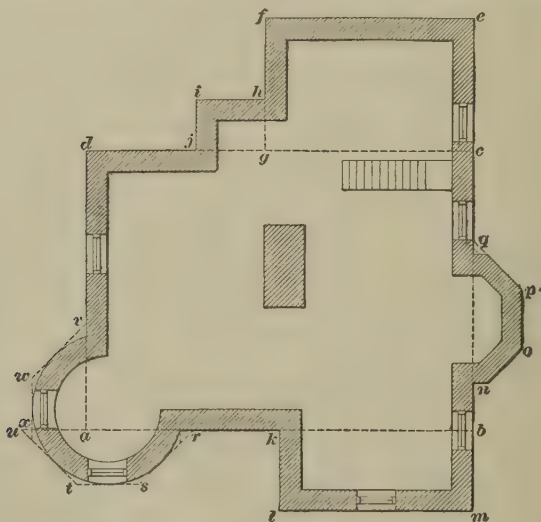


FIG. 1.

regular; but when the outlines are very irregular and broken, the easiest method to calculate the excavation is to divide the plan into geometrical figures which are easy to compute, and calculate the area of each one separately. These areas being added, and their sum multiplied by the depth of the cellar, will give the volume of the excavation.

An illustration of this method is shown in Fig. 1, which represents the plan of an irregular foundation. To compute the area of the excavation, the plan is divided into the rectangles $adcb$, $lkbm$, $jihg$, $gfec$, and the polygons $nqpo$, $turs$, and $axwv$. By scaling on the drawing the dimensions of these figures, the area of each may then be readily determined by calculation.

It is sometimes required to find the volume of an excavation, the surface of which is very irregular, as in Fig. 2; in

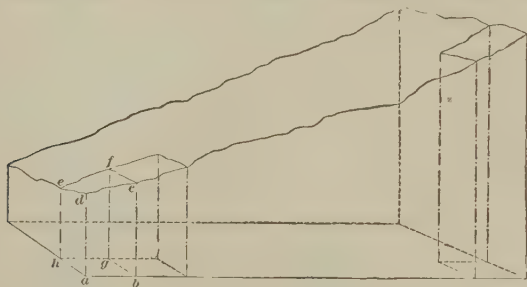


FIG. 2.

such a case the following method may be used: Divide the surface of the excavation into a number of squares or rectangles, as at $defc$; these represent the ends of prisms, the other ends of which are the bottom of the excavation, as at $ahgb$. Then calculate the volume of each prism by ascertaining the height of the four corners above the bottom; add these measurements together, divide the sum by 4 (the number of corners), and multiply the result by the end area, as $ahgb$; the product will be the volume of the prism. The sum of these partial volumes will be an accurate estimate of the contents of the excavation.

MASONRY.

9. Stone Masonry.—This is generally measured by the perch; in some sections of the country, however, measurement by the cord is preferred, but the best method (as being invariable) is by the cubic yard. In estimating by the perch, it should be stated how much the perch is taken at, whether

24 $\frac{3}{4}$ or 25 cubic feet. Note should also be made in regard to corners and deduction for openings; in most localities it is not customary to deduct openings under a certain size, and corners are usually measured twice.

Rough stone from the quarry is generally sold under two classifications; namely, rubble and dimension stone. *Rubble* consists of pieces of irregular size, such as are most easily obtained from the quarry, up to 12 inches in thickness by 24 inches in length. Stone ordered of a certain size, or to square over 24 inches each way and to be of a particular thickness, is called *dimension stone*.

Rubble masonry and stone backing are generally figured by the perch or cubic yard. Dimension-stone footings are measured by the square foot unless they are built of large irregular stone, in which case they are measured the same as rubble. Ashlar work is always figured by the superficial foot; openings are usually deducted, and the jambs are measured in with the face work. Flagging and slabs of all kinds, such as hearths, treads for steps, etc., are measured by the square foot; sills, lintels, molding, belt courses, and cornices, by the lineal foot, and irregular pieces are generally figured by the cubic foot. All carved work is done at an agreed price by the piece.

DATA ON RUBBLE MASONRY.

10. The following proportions and cost of materials, and amount of labor required to lay 1 perch of rubble masonry, are reasonably accurate, and will serve to give an idea of how to estimate such work.

COST OF RUBBLE MASONRY.

Using 1-to-3 Lime Mortar.

1 perch stone (25 cubic feet) delivered at work.....	\$1.25
1 bushel lime.....	.25
$\frac{1}{6}$ load of sand, at \$1.50 per load.....	.25
$\frac{1}{8}$ day mason's labor, at \$2.50 per day.....	.83
$\frac{1}{4}$ day helper's labor, at \$1.50 per day.....	.38
Total cost.....	\$2.96

Using 1-to-3 Portland Cement Mortar.

1 perch stone.....	\$1.25
$\frac{1}{2}$ barrel Portland cement, at \$2.60 per barrel.....	1.30
$\frac{1}{6}$ load sand, at \$1.50 per load.....	.25
$\frac{1}{8}$ day mason's labor, at \$2.50 per day.....	.83
$\frac{1}{4}$ day helper's labor, at \$1.50 per day.....	.38
Total cost.....	\$4.01

Using 1-to-3 Rosendale Cement Mortar.

1 perch stone.....	\$1.25
$\frac{1}{2}$ barrel Rosendale cement, at \$1.25 per barrel.....	.63
$\frac{1}{6}$ load sand, at \$1.50 per load.....	.25
$\frac{1}{8}$ day mason's labor, at \$2.50 per day.....	.83
$\frac{1}{4}$ day helper's labor, at \$1.50 per day.....	.38
Total cost.....	\$3.34

DATA ON ASHLAR AND CUT STONE.

11. Cost.—The following figures are average prices of stone when the transportation charges are not excessive, and are not given as fixed values, but more to show the relative costs. They are based on quarrymen's wages of \$2.25 per day, and stone-cutters' wages of \$3.00 per day.

First-class rock-face bluestone ashlar, with from 6 to 10 inch beds, dressed about 3 inches from face, will cost, ready for laying, from 25 to 40 cents per square foot, face measure; while very good work will cost from 35 to 45 cents per square foot. Regular course bluestone ashlar, 12 to 18 inches high, with from 8 to 12 inch beds, will cost about 50 cents per square foot. To this (and the previous figures) must be added the cost of hauling, which, on an average, will be about 2 cents per square foot. The cost of setting ashlar may be taken at about 10 cents per square foot.

The rough stock for dimension stone will cost, at the quarry, if Quincy granite, in pieces of a cubic yard or less, from 50 cents to 75 cents per cubic foot; if bluestone, about 50 cents; if Ohio sandstone, about 30 cents per cubic foot; if Indiana limestone, about 25 cents per cubic foot; and if Lake Superior redstone, about 40 cents per cubic foot.

Flagstones for sidewalks, ordinary stock, natural surface, 3 inches thick, with joints pitched to line, in lengths (along walk) from 3 to 5 feet, will cost, for 3-foot walk, about 8 cents per square foot (if 2 inches thick, 6 cents); for 4-foot walk, 9 cents; and for 5-foot walk, 10 cents per square foot. The cost of laying all sizes will average about 3 cents per square foot. The above figures do not include cost of hauling.

Curbing, 4"×24", granite, will cost, at quarry, from 25 to 30 cents per lineal foot; digging and setting will cost from 10 to 12 cents additional; and the cost of freight and hauling must also be added.

The following figures show the approximate cost of cut bluestone for various uses:

Flagstone, 5-inch, size 8'×10', edges and top bush hammered, per sq. ft., face measure.....	\$0.65
Flagstone, 4-inch, size 5'×5', select stock, edges clean cut, natural top, per sq. ft.....	.30
Door sills, 8"×12", clean cut, per lin. ft.....	1.25
Window sills, 5"×12", clean cut, per lin. ft.....	.80
Window sills, 4"×8", clean cut, per lin. ft.....	.45
Window sills, 5"×8", clean cut, per lin. ft.....	.60
Lintels, 4"×10", clean cut, per lin. ft.....	.60
Lintels, 8"×12", clean cut, per lin. ft.....	1.10
Steps, sawed stock, 7"×14", per lin. ft.....	.90
Water-table, 8"×12", clean cut, per lin. ft.....	1.25
Coping, 4"×21", clean cut, per lin. ft.....	1.10
Coping, 4"×21", rock-face edges and top, per lin. ft.	.45
Coping, 3"×15", rock-face edges and top, per lin. ft.	.25
Coping, 3"×18", rock-face edges and top, per lin. ft.	.30
Platform, 6" thick, per sq. ft.....	.45

To the prices of cut stone above given, must be added the cost of setting, which for water-tables, steps, etc. will be about 10 cents per lineal foot; and for window sills, etc., about 5 cents per lineal foot. In addition, allow about 10 cents per cubic foot for fitting, and about 5 cents per cubic foot for trimming the joints after the pieces are set in place.

12. Day's Work.—A stone cutter can cut about 6 square feet of granite per day, 8 square feet of bluestone, and about 10 square feet of Ohio sandstone or limestone. These figures are for 8-cut patent-hammered work. For rock-face ashlar (beds worked about 3 inches from face, the rest pitched), a workman can dress from 25 to 28 square feet per day, of random ashlar; and from 18 to 20 square feet of coursed ashlar. In dressing laminated stone, from two to three times more work can be done in a day on the natural surface than on the edge of layers. In figuring cut stone, an ample allowance should be made for waste, which, on an average, will be 25 per cent.

BRICKWORK.

13. Brickwork is generally estimated by the thousand bricks laid in the wall, but measurements by the cubic yard and the perch are also used. The following data will be useful in calculating the number of brick in a wall. For each superficial foot of wall 4 inches (the width of one brick) in thickness, allow $7\frac{1}{2}$ bricks; for a 9-inch (the width of two bricks) wall, count 15 bricks; for a 13-inch (the width of three bricks) wall, allow $22\frac{1}{2}$ bricks; and so on, estimating $7\frac{1}{2}$ bricks for each additional 4 inches in thickness of the wall. The above figures are for the ordinary eastern standard brick, which is about $8\frac{1}{2}$ in. $\times$ 4 in. $\times$ $2\frac{1}{4}$ in. If smaller brick is used, the figures will be increased proportionately. If brickwork is estimated by the cubic yard, allow 500 brick to a yard. This figure is based on the use of brick of the size above given, and mortar joints not over $\frac{3}{8}$ inch thick. If the joints are $\frac{1}{2}$ inch thick, as in face brickwork, 1 cubic yard will require about 575 bricks. In making calculations of the number of bricks required, an allowance of, say, 5 per cent. should be made for waste in breakage, etc.

The practice in regard to deductions for openings is not uniform throughout the country, but usually small openings are counted solid, as the cost of the extra labor and the waste in working around these places balances that of the

brickwork saved. All large openings, 100 square feet or over in area, should be deducted.

When openings are measured solid, it is not usual to allow extra compensation for arches, pilasters, corbels, etc. Rubbed and ornamental brickwork should be measured separately, and charged for at a special rate.

Brick footings may be computed by the lineal foot. The following table, based on steps or offsets of one-quarter brick, or 2 inches, for each course in the footing, gives the number of bricks per lineal foot in footings for brick walls from 9 to 26 inches thick:

9-inch wall.....	10½ bricks per lin. ft.
13-inch wall.....	22½ bricks per lin. ft.
18-inch wall.....	39 bricks per lin. ft.
22-inch wall.....	60 bricks per lin. ft.
26-inch wall.....	85¼ bricks per lin. ft.

DATA ON BRICKWORK.

14. The following estimates on the cost of brickwork are very carefully compiled, and will be found trustworthy. It is to be understood that the prices will vary with the cost of materials and labor; but the proportions will be constant. The figures are based on *kiln*, or actual, count—that is, with deductions for openings. When the work is measured with no deductions for openings, the cost per thousand may be assumed as about 15 per cent. less than the prices given, which are exclusive of builder's profit.

COST OF COMMON BRICKWORK PER THOUSAND BRICK.

Using 1-to-3 Lime Mortar.

1,000 brick.....	\$6.00
3 bu. lime, at 25 cents per bu.....	.75
½ load sand (10 bbl. to load), at \$1.50 per load.....	.75
Bricklayer, 7 hours, at 35 cents per hour.....	2.45
Laborer, 7 hours, at 15 cents per hour.....	1.05
Total.....	\$11.00

Using 1-to-3 Portland Cement Mortar.

1,000 brick	\$6.00
1½ bbl. Portland cement, at \$2.60 per bbl.....	3.90
½ load sand.....	.75
Bricklayer, 7 hours, at 35 cents per hour.....	2.45
Laborer, 7 hours, at 15 cents per hour.....	1.05
Total.....	\$14.15

Using 1-to-4 Lime-and-Cement Mortar.

1,000 brick.....	\$6.00
3 bu. lime, at 25 cents per bu.....	.75
½ load sand.....	.75
1 bbl. cement.....	2.60
Bricklayer, 7 hours, at 35 cents per hour.....	2.45
Laborer, 7 hours, at 15 cents per hour.....	1.05
Total.....	\$13.60

Using 1-to-3 Rosendale Cement Mortar.

1,000 brick.....	\$6.00
1½ bbl. Rosendale cement, at \$1.25 per bbl.....	1.87
½ load sand.....	.75
Bricklayer, 7 hours, at 35 cents per hour.....	2.45
Laborer, 7 hours, at 15 cents per hour.....	1.05
Total.....	\$12.12

COST OF PRESSED BRICKWORK PER THOUSAND BRICK.

Using Lime-Putty Mortar.

1,000 pressed brick, cost from \$20 to \$40 (average)..	\$30.00
1½ bu. lime.....	.38
¼ load fine sand.....	.37
Bricklayer, 30 hours, at 40 cents per hour.....	12.00
Laborer, 15 hours, at 15 cents per hour.....	2.25
Total.....	\$45.00

CARPENTRY.

15. Carpentry should include general framing, roofs, floor joists, partitions, sheathing, flooring, furring, and plastering grounds.

16. Board Measure.—The rough lumber used in framing is measured by the board foot, which means a piece 12 inches square and 1 inch thick. Lumber is always sold on a basis of a thousand feet board measure; the customary abbreviation for the latter term is B. M.; that for thousand is M; thus, 500 feet board measure, costing \$14.00 per thousand, would be written: 500 ft. B. M., at \$14.00 per M.

To obtain the number of board feet in any piece of timber, the length of the scantling in inches is multiplied by the end area in inches, and the result is divided by 144. For example, the number of feet B. M. in a floor joist, 20 feet long, 3 inches thick, and 10 inches deep, will be: 240 in. ($= 20 \text{ ft.} \times 12$) multiplied by 30 sq. in. (the end area), and the product divided by 144, giving 50 feet B. M.

The following rule is that used by most contractors and lumber dealers: *Multiply the length in feet by the thickness and width in inches, and divide the product by 12.* Thus, a scantling 26 feet long, 2 inches thick, and 6 inches wide contains $\frac{26 \times 2 \times 6}{12} = 26$ feet B. M.

This rule, expressed in a slightly different manner, is more convenient for mental computation: *Divide the product of the width and thickness in inches by 12, and multiply the quotient by the length in feet.* Thus, a 2" $\times$ 10" plank, 18 feet long, contains $\frac{2 \times 10}{12} \times 18 = 30$ feet B. M.

17. Studs.—To calculate the number of studs—set on 16-inch centers—the following rule may be used: *From the*

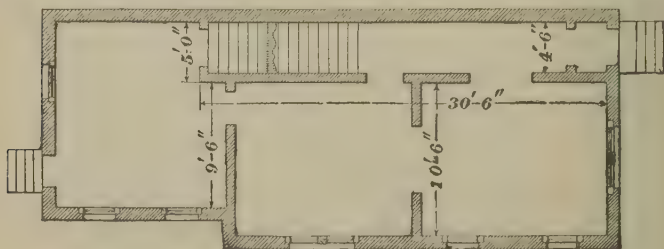


FIG. 8.

length of the partition deduct one-fourth, and to this result add 1. Count the number of returns, or corners, on the plan, and add 2 studs for each return. (The reason for adding 1 is to include the stud at the end, which would otherwise be omitted.) The sills, plates, and double studs must be measured separately.

For example, the number of studs required for partitions shown on the plan, Fig. 3, is computed as follows: The lengths are:

30 ft. 6 in.	Deducting one-quarter from 60 feet, the
10 ft. 6 in.	remainder is 45 feet; adding 1 stud, the result is
9 ft. 6 in.	46 feet. As there are 4 returns, with 2 studs for
5 ft. 0 in.	each, the total number is $46 + (4 \times 2) = 54$ studs.
4 ft. 6 in.	As a general rule, when (as is usual) the studs
60 ft. 0 in.	are set at <i>16-inch</i> centers, <i>1 stud for each foot in</i>

length of partition will be a sufficient allowance to include sills, plates, and double studs. Thus, if the total length of partitions is 75 feet, 75 studs will be sufficient for sills, double studs, etc. If the studs are set at *12-inch* centers, the number required will be equal to the *number of feet in length of partition plus one-fourth*. Thus, if the length of partitions is 72 feet, $72 + 18$, or 90, studs will include those required for sills, plates, etc.

The same rules may be used for calculating the number of joists, rafters, tie-beams, etc.

A good way to estimate bridging is to allow 2 cents apiece, or 4 cents per pair; this will be sufficient to furnish and set a pair made of 2" $\times$ 3" spruce or hemlock stuff.

18. Sheathing.—To calculate sheathing or rough flooring (which is not matched), find the number of feet B. M. required to cover the surface, making no deductions for door or window openings, for what is gained in openings is lost in waste. If the sheathing is laid horizontally, only the actual measurement is necessary; but if it is *laid diagonally*, add 8 or 10 per cent. to the actual area.

19. Flooring.—In estimating matched flooring, a square foot of $\frac{7}{8}$ -inch stuff is considered to be 1 foot B. M. If the flooring is 3 inches or more in width, add *one-quarter* to the

actual number of board feet, to allow for waste of material in forming the tongue and groove; if less than 3 inches wide, *add one-third*. Flooring of $1\frac{1}{2}$ -inch finished thickness is considered to be $1\frac{1}{4}$ inches thick, and for calculating it the following rule may be used: *Increase the surface measure 50 per cent.* (This consists of 25 per cent. for extra thickness over 1 inch, and 25 per cent. for waste in tonguing and grooving.) To this amount add 5 per cent. for waste in handling and fitting.

In figuring the area of floors, openings for stairs, fireplaces, etc. should be deducted.

20. Weather boarding or siding is usually measured by the superficial foot. No deduction should be made for ordinary window or door openings, as these usually balance the waste in cutting and fitting. Careful attention must be given to the allowance for lap. If 6-inch, nominal width (actual width, $5\frac{1}{2}$ inches), siding, laid with 1-inch lap, is used, *add one-quarter* to the actual area, in order to obtain the number of square feet of siding required. If 4-inch stuff is used, *add one-third* to the actual area. When, as above noted, no allowance is made for openings, the corner and baseboards need not be figured separately.

21. Cornices may be measured by the running foot, the molded and plain members being taken separately. A good method of figuring cornices is as follows: *Measure the girth, or outline, and allow 1 cent for each inch of girth, per lineal foot.* This price will pay for material and for setting, the cost of the mill work being estimated at 50 per cent.

22. Cost per Square Foot.—For all classes of materials which enter into the general framing and covering of a building, a close estimate may be made by analyzing the cost per square foot of surface; that is, the cost of labor and materials—studs and sheathing in walls, joists and flooring in floors, etc.—required for a definite area, should be closely determined, and this cost, divided by the area considered, will give the price per square foot. If the corresponding whole area is multiplied by the figure thus obtained, the

result will, of course, be the cost of that portion of the work. While it is usual to adopt a uniform rate for the various grades of work, a careful analysis will show that roof sheathing in place costs more than wall sheathing, owing to its position; and that the studs in walls and partitions cost more than floor joists, as they are lighter and require more handling.

The following example shows how to determine the cost per square foot of flooring, and indicates the general method to be pursued in like cases. The area used in the calculation is a square, or 100 square feet. The cost of labor is estimated at 50 per cent. of that of the materials, which experience has shown to be a very close approximation to the actual cost of general carpenter work.

COST OF FINISHED FLOOR PER SQUARE.

Joists, hemlock, 8 pieces, 3"×10"×10', 200 ft. B. M., at \$14 per M	\$2.80
Bridging, hemlock, 7 sets, 2"×3"×1' 4", 9 ft. B. M., at \$14 per M	.13
Rough flooring, hemlock, $\frac{7}{8}$ inch thick, laid diagonally, 100 ft. + 25 ft. + 10 ft., 135 ft. B. M., at \$17 per M	2.29
Finished flooring, white pine, $\frac{7}{8}$ inch thick, 125 ft. B. M., at \$22 per M	2.75
Nails, (about) 3 lb., at \$1.80 per 100 lb.	.05
Labor, 50 per cent. of cost of materials	4.01
Total cost for 100 sq. ft.	\$12.03
Cost per square foot, $\$12.03 \div 100 =$	12 cents.

A similar method may be followed in estimating the cost of interior finish, paneling, doors, etc.

23. The quantity of material that a workman will put in place in a day is very uncertain, depending upon the skill of the artisan, his rapidity of working, and the ease or difficulty of the work, all somewhat modified by numerous accidental circumstances. The subjoined figures, while founded on information gained by many years of experience, are only

intended to give an idea of the relative quantities, and are not a standard to be adhered to in all cases. The estimates are based on a 9-hour day, and wages at \$2.25 per day. If the hours or pay are less or greater, the results will be correspondingly diminished or increased. Unless otherwise noted, the figures represent the labor of two men working together.

QUANTITIES OF MATERIAL PUT IN PLACE PER DAY.

Class of Material.	No. of Feet B. M., or No.	Remarks.
Studding, 2" × 4", or 2" × 6" ..	600-800	Wall or partition.
Rafters.....	500-600	
Floor joists, 2" × 10", or 3" × 12"	1,500	
Sheathing, unmatched.....	1,000	Laid horizontally.
Sheathing, unmatched.....	800	Laid diagonally.
Sheathing, matched.....	800	Laid horizontally.
Sheathing, matched.....	600	Laid diagonally.
Sheathing, roof.....	1,000	Plain gable roof.
Sheathing, roof.....	500	{ Much cut up by hips, valleys, dormers, etc.
Siding.....	700	{ Includes fitting and setting corner boards, base, trim, and scaffolding.
Posts and beams over cellars.	400-500	{ Includes scarfing and doweling.
Plaster grounds, lineal feet, per man.....	{ 400	{ For base and wain- scot, straight- ened in good shape.
Bridging, No. pairs per hour, per man.....	{ 12	{ Includes cutting and setting.
False jambs around openings, per hour, per man.....	{ 1	

COST OF MISCELLANEOUS ITEMS OF CARPENTRY.

Class of Work.	Cost.	Remarks.
Setting window frames in wood buildings.....	\$0.30	Per sq. ft. (about 1 hour time).
Furring brick walls, 1"×2" strips, 12-inch centers....	.02½	Per sq. ft. (includes labor, material, and nails).
Furring brick walls, 1"×2" strips, 16-inch centers....	.01⅞	Per sq. ft.
Cutting holes and fitting plugs in brick walls, 12-inch centers.....	.02	Per sq. ft.
Cutting holes and fitting plugs in brick walls, 16-inch centers.....	.01¾	Per sq. ft.
Window frames in brickwork.	.50	Each (includes nails and bracing).
Door frames in brickwork....	.50	Each.
Window frames in stonework.	1.25	Each, for ordinary work.
Window frames in stonework.	2.00	Each, for very careful work.
Door frames in stonework....	2.00	Each, for very careful work.
Furnishing and setting trimmer-arch centers	1.25	Each.
Arch centers, 3½ ft. span, 8-in. reveal.....	1.00	Each (includes supports and wedges).

24. Nails.—To calculate the quantity of nails required in executing any portion of the work, the following table, based on the use of cut nails, will be found useful:

TABLE FOR ESTIMATING THE QUANTITY OF NAILS.

Material.	Lb. Required.	Kind of Nails.
1,000 shingles.....	5	4d.
1,000 laths.....	7	3d.
1,000 sq. ft. beveled siding.....	18	6d.
1,000 sq. ft. sheathing.....	20	8d.
1,000 sq. ft. sheathing.....	25	10d.
1,000 sq. ft. flooring.....	30	8d.
1,000 sq. ft. flooring.....	40	10d.
1,000 sq. ft. studding.....	15	10d.
	5	20d.
1,000 sq. ft. furring 1"×2".....	10	10d.
1,000 sq. ft. $\frac{7}{8}$ " finished flooring.	20	8d. to 10d. finish.
1,000 sq. ft. $1\frac{1}{8}$ " finished flooring.	30	10d. finish.

The following table gives the name, length, and number per pound of various sizes of nails:

SIZES AND WEIGHTS OF NAILS.

Name.	Length in Inches.	No. per Lb.
3d. fine.....	$1\frac{1}{8}$	588
3d. common.....	$1\frac{1}{8}$	488
4d. common.....	$1\frac{3}{8}$	336
5d. common.....	$1\frac{1}{2}$ to $1\frac{3}{4}$	216
6d. finish.....	2	204
6d. common.....	2	166
7d. common.....	$2\frac{1}{4}$	118
8d. finish.....	$2\frac{1}{2}$	102
8d. common.....	$2\frac{1}{2}$	94
10d. finish.....	3	80
10d. common.....	$2\frac{3}{4}$	72
12d. common.....	$3\frac{1}{8}$	50
20d. common.....	$3\frac{3}{4}$	32
30d. common.....	$4\frac{1}{4}$	20
40d. common.....	$4\frac{3}{4}$	17
50d. common.....	5	14
60d. common.....	$5\frac{1}{2}$	10

ROOFING.

25. Kinds of Roof Covering.—The roof coverings most generally used are shingles, slate, tin, tile, and tarred paper and gravel (known as gravel roofing). While there are slight variations in the methods of measuring the different kinds, they are all based on the square of 100 square feet.

26. Shingles.—In measuring shingle roofing, it is necessary to know the exposed length of a shingle; this is found by deducting 3 inches—the usual cover over the head of the lowest shingle in the four overlapping courses—from the length; dividing the remainder by 3, the result will be the exposed length, and multiplying this by the average width of a shingle, the product will be the exposed area. Dividing 14,400, the number of square inches in a square, by the exposed area of 1 shingle, will give the number required to cover 100 square feet of roof. For example, it is required to compute the number of shingles 18 in. $\times$ 4 in. necessary to cover 100 square feet of roof. With a shingle of this length, the exposure will be $\frac{18-3}{3} = 5$ inches; then the exposed area of 1 shingle is 4 in. $\times$ 5 in., or 20 square inches, and 1 square requires $14,400 \div 20 = 720$ shingles.

An allowance should always be made for waste in estimating the number of shingles required.

The following table is arranged for shingles from 16 inches to 27 inches in length, 4 inches and 6 inches in width, and for various lengths of exposure:

TABLE FOR ESTIMATING SHINGLES.

Exposure to Weather.	No. of Sq. Ft. of Roof Covered by 1,000 Shingles.		No. of Shingles Required for 100 Sq. Ft. of Roof.	
	4 In. Wide.	6 In. Wide.	4 In. Wide.	6 In. Wide.
4 inches.....	111	167	900	600
5 inches.....	139	208	720	480
6 inches.....	167	250	600	400
7 inches.....	194	291	514	343
8 inches.....	222	333	450	300

Shingles are classed as *shaved* or *breasted*, and *sawed* shingles. The former vary from 18 to 30 inches in length, and are about $\frac{1}{2}$ inch thick at the butt and $\frac{1}{16}$ inch at the top; the latter are usually from 14 to 18 inches long, and of various thicknesses. In the case of 18-inch shingles, there are 5 shingles to $2\frac{1}{4}$ inches; that is, the thickness at the butt is $2\frac{1}{4} \div 5 = .45$ inch, or about $\frac{7}{16}$ inch; and at the top the thickness is $\frac{1}{16}$ inch.

Strictly first-class shingles are generally given a brand of "XXX," and those of a slightly poorer quality are termed No. 2; but in some sections of the country, the brand "A" is general; thus, "Choice A" or "Standard A" are practically equivalent to the "XXX" shingle.

Shaved shingles are usually packed in bundles of 500, or 2 bundles per thousand. Sawed shingles are made up into bundles of 250, and are sold on a basis of 4 inches width for each shingle. If the wider ones are ordered, the cost per thousand is correspondingly increased. For example, if one thousand 4-inch shingles were required to cover an area, and 6-inch ones were ordered, only two-thirds as many, or 667, would be needed and furnished, while the cost would be that of 1,000 standard-width shingles.

Shingles cost from \$3.00 to \$5.00 per thousand, according to material and grade. Dimension shingles—those cut to a uniform width—if of prime cedar, shaved, $\frac{1}{2}$ inch thick at the butt and $\frac{1}{16}$ inch at the top, will cost \$9.00 to \$10.00 per thousand, but such shingles are usually 6 inches wide and 24 inches long, so that a less number will be required per square than of ordinary shingles.

A fairly good workman will lay about 1,500 shingles per day of 9 hours, on straight, plain work; while in working around hips and valleys, the average will be about 1,000 per day.

27. Slating.—In measuring slating, the method of determining the number of slates required per square is similar to that given for shingling; but in slating, each course overlaps but two of the course below, instead of three, as in

shingling. The usual lap, or cover of the lowest course of slate by the uppermost of the three overlapping courses, is 3 inches; hence, to find the exposed length, deduct the lap from the length of the slate, and divide the remainder by 2. The exposed area is the width of the slate multiplied by this exposed length, and the number of slates required per square is found by dividing 14,400 by the exposed area of 1 slate. Thus, if 14"×20" slate are to be used, the exposed length will be $\frac{20-3}{2} = 8\frac{1}{2}$ inches; the exposed area will be $14 \times 8\frac{1}{2} = 119$ square inches, and the number per square will be $14,400 \div 119 = 121$ slates.

The following rules should be observed in measuring slating: Eaves, hips, valleys, and cuttings against walls are measured extra, 1 foot wide by their whole length—the extra charge being made for waste of material and the increased labor required in cutting and fitting. Openings less than 3 square feet are not deducted, and all cuttings around them are measured extra. Extra charges are also made for borders, figures, and any change in color of the work, and for steeples, towers, and perpendicular surfaces.

The following table, based on 3 inches lap, gives the sizes of the American slates, and the number of pieces required per square:

NUMBER OF SLATES PER SQUARE.

Size. Inches.	Number of Pieces.	Size. Inches.	Number of Pieces.	Size. Inches.	Number of Pieces.
6×12	533	9×16	246	14×20	121
7×12	457	10×16	221	11×22	138
8×12	400	9×18	213	12×22	126
9×12	355	10×18	192	13×22	116
7×14	374	11×18	174	14×22	108
8×14	327	12×18	160	12×24	114
9×14	291	10×20	169	13×24	105
10×14	261	11×20	154	14×24	98
8×16	277	12×20	141	16×24	86

The cost of slating varies from 7 to 9 cents per square foot, depending on the class of work.

28 Tin Roofs.—In estimating tin (and also other metal) roofs, hips and valleys are measured extra their entire length by 1 foot in width, to compensate for increased labor and waste of material in cutting and laying. Gutters and conductor pipes and leaders are measured by the lineal foot, 1 foot extra being added for each angle. All flashings and crestings are measured by the lineal foot. For seams, addition is made to superficial area, depending on the kind of seam used, whether single lock, standing, or roll and cap. No deductions are made for openings (chimneys, skylights, ventilators, or dormer-windows), if less than 50 square feet in area; if between 50 and 100 square feet, one-half the area is deducted; if over 100 square feet, the whole opening is deducted. An extra charge is made for labor and waste of material to flash around such openings.

A box of roofing tin contains 112 sheets 14 in. $\times$ 20 in., and weighs from 110 to 145 pounds per box, according to whether it is IC or IX plate. The IC plate, which is the most used, weighs about 8 ounces per square foot, and the IX, about 10 ounces. As there are considerable variations in the weights of tin made by different manufacturers, a fair average will be obtained by estimating IC tin at 1 pound, and IX tin at $1\frac{1}{4}$ pounds per sheet. Double-size roofing tin can be had 20 in. $\times$ 28 in., weighing, if IC, 225 pounds per box. This size is the most economical, as by its use much material and labor are saved, on account of the less number of seams and ribs required.

A 14" $\times$ 20" sheet will cover about 235 square inches of surface, using standing joints; or a box will cover about 182 square feet. With a flat lock seam, a sheet will cover 255 square inches, allowing $\frac{3}{8}$ inch all around for joints; or a box will lay 198 square feet. These figures make no allowance for waste.

Two good workmen can put on, and paint outside, from 250 to 300 square feet of tin roofing per day of 8 hours.

Tin roofing will cost from 8 to 10 cents per square foot, depending on the quality of material and workmanship.

29. **Tile roofs** are constructed of so many styles of tile that no general rules of measurement can be given, and every piece of work must be estimated according to the particular kind of tile used and the number of sizes and patterns. Information on all these points are to be found in the catalogues of tile manufacturers.

30. In gravel roofing the cost per square depends upon the number of thicknesses of tarred felt and the quantity of pitch used per square.

ROOF MENSURATION.

31. While the ordinary principles of mensuration are all that are necessary to calculate any roof area, yet the modern house, with its numerous gables and irregular surfaces, introduces complications which render some further explanation of roof measurement desirable. The most common error made in figuring roofs—and which should be carefully guarded against—is that of using the apparent length of slopes, as shown by the plan or side elevations, instead of the true length, as obtained from the end elevations.

32. The area of a plain gable roof, as shown in end and side elevations in Fig. 4, is found by multiplying the length gj by the slope length bd , and further multiplying by 2, for

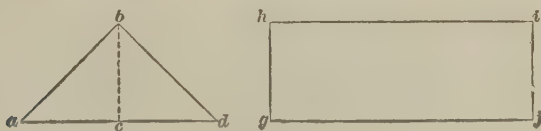


FIG. 4.

both sides. The area of the gable is found by multiplying the width of the gable ad by the altitude cb , and dividing by 2.

33. In Fig. 5 is shown the plan and elevation of a hip roof, having a deck z . The pitch of the roof being the same

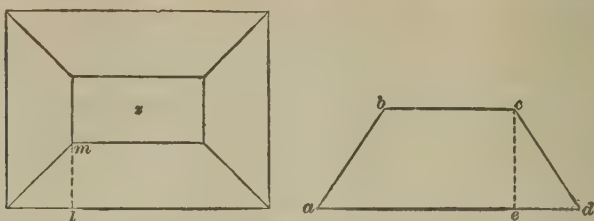


FIG. 5.

on each side, the line cd shows the true length of the common rafter lm . In Fig. 6 is shown the method of developing

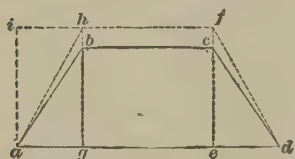


FIG. 6.

the true lengths of the hips, and the true size of one side of the roof. Let $abcd$ represent the same lines as the corresponding ones in Fig. 5. From the line ad , through b and c , draw perpendiculars, as gh and ef ; lay off from g and e on these lines, the length of the common rafter ab , Fig. 5, and draw the lines ah and df ; then the figure $ahfd$ will show the true shape and size of the roof shown in the elevation in Fig. 5. The area of the triangle def is equal to the area of the triangle agh or a similar triangle aih . Hence, the portion of the roof $ahfd$ is equal in area to the rectangle $aife$, the length of which is half the sum of the eave and deck lengths, while its breadth is the length of a common rafter.

34. A method of obtaining the lengths of valley rafters, applicable also to hip rafters, is shown in Fig. 7, which is the plan of a hip-and-gable roof. To ascertain the length of the valley rafter ab , draw the line ac perpendicular to ab , and equal in length to the altitude of the gable; then

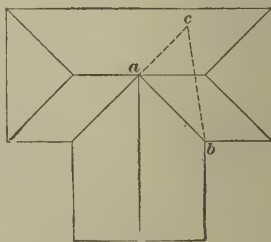


FIG. 7.

draw the line cb , which will be the true length of the valley rafter ab .

35. As an example of roof mensuration, the number of square feet of surface on the roof shown in Fig. 8 will be calculated.

The area of the triangular portion acb is equal to the

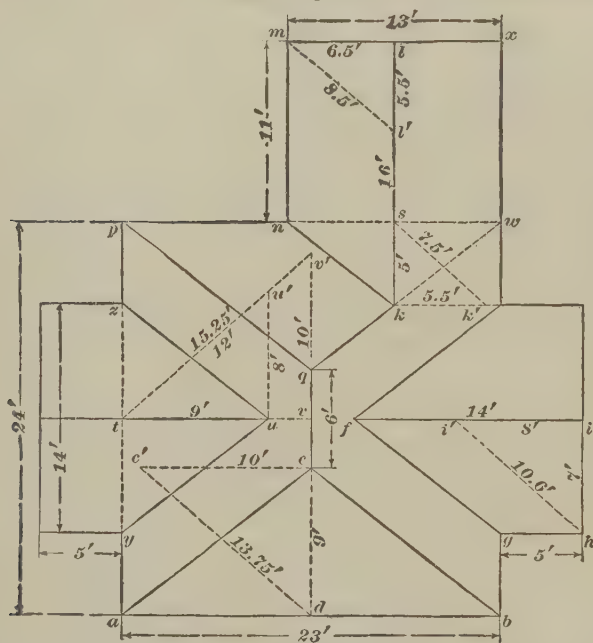


FIG. 8.

slope length of dc —found by laying off $c'c$ equal to the height of the ridge above the eaves and drawing $c'd$ —multiplied by the length of the eaves line ab and divided by 2. Multiplying the dimensions 13.75 feet and 23 feet, respectively, and dividing by 2, the area is found to be 158.1 square feet.

The area of the trapezoid $gfih$ is half the sum of fi and gh —shown in their true length on the plan—multiplied by the true length of hi . The latter is found by marking the

height of the gable ii' on the ridge line, and drawing the line $i'h$, which measures $10\frac{2}{3}$ feet. Performing these operations, there results $\frac{5+14}{2} \times 10\frac{2}{3} = 101.3$ square feet for each side, or 202.6 square feet for both. As the side gables are the same size, the area of the two roofs is $202.6 \times 2 = 405.2$ square feet.

The area of the polygon $qpnh$ is equal to the triangle qpw minus the triangle knw , the area covered by the intersecting gable roof. The former is equal to the triangle acb , the area of which is 158.1 square feet. The area of knw is equal to half of nw , or 6.5 feet, multiplied by the true altitude of the triangle; the latter is obtained by laying off kk' equal to the height of the gable, 5.5 feet, at right angles to ks , and drawing sk' , which is the required altitude, and which measures 7.5 feet. Then $knw = 6.5 \times 7.5 = 48.7$ square feet; whence $qpnh$ equals $158.1 - 48.7 = 109.4$ square feet.

The area of $apqc$ is $\frac{ap+qc}{2}$ multiplied by the true slope length of tv , or tv' , which measures 15.25 feet. Substituting dimensions, the area is found to be $\frac{6+24}{2} \times 15.25 = 228.7$ square feet. From this deduct the area of ysu , which is the portion covered by the intersecting gable roof. The true length of tu along the slope is tu' , measuring 12 feet; hence the area of ysu is $\frac{14 \times 12}{2} = 84$ square feet. The net area of $apqc$ is, therefore, $228.7 - 84 = 144.7$ square feet; $bcqw$ being equal to $apqc$, its area is the same, making the area of both sides 289.4 square feet.

The area of $knml$ is $\frac{mn+lk}{2} \times ml'$, the slope length of ml . Substituting dimensions, the area is $\frac{11+16}{2} \times 8.5 = 114.7$ square feet. As $klxw$ is equal to $knml$, the area of both is 229.4 square feet.

Adding the partial areas thus obtained, the sum is $158.1 + 405.2 + 109.4 + 289.4 + 229.4 = 1,191.5$ sq. ft., or 11.9 squares.

PLASTERING.

36. Plastering on plain surfaces, such as walls and ceilings, is always measured by the square yard; but there are considerable variations in detail in the methods of measurement in different sections of the country. The following rules, however, probably represent the average practice, and are equitable to both parties concerned.

On walls and ceilings, measure the surface actually plastered, making no deduction for grounds, or for openings of less extent than 7 superficial yards.

Returns of chimney breasts, pilasters, and all strips of plastering less than 12 inches in width, measure as 12 inches wide.

In closets, add one-half to the actual measurement; if shelves are put up before plastering, charge double measurement.

For raking ceilings or soffit of stairs, add one-half to measurement; for circular or elliptical work, charge two prices; for surfaces of domes or groined ceilings, three prices.

Round corners and arrises (other than chimney breasts) should be measured by the lineal foot.

On interior work, increase the price 5 per cent. for each 12 feet above the ground after the first. For outside work, add 1 per cent. for each foot above the lower 20 feet.

All repairing and patching should be done at agreed prices.

37. Stucco Work.—Cornices composed of plain members and panel work are measured by the square foot. Enriched cornices with carved moldings are measured by the lineal foot. When moldings are less than 12 inches in girth, measurement is taken by the lineal foot; when over 12 inches, superficial measurement is used. For internal angles or miters, add 1 foot to length of cornice, and for exterior angles add 2 feet to length. Sections of cornice less than 12 inches measure as 12 inches. Add one-half for raking cornices.

For cornices or moldings abutted against wall or plain surface, add 1 foot to length of cornice; if against soffit of stairs or other inclined or covered surface, add 2 feet to length of cornice. Octagonal, hexagonal, and similar cornices, less than 10 feet in single stretches, take one and one-half times the length.

For circular or elliptical work charge double price; for domes and groins, three prices. Enrichments of all kinds should be estimated at an agreed price.

38. The quantity of plastering which can be done in a day varies considerably with the class of work, but for ordinary good 3-coat work, two plasterers, with one laborer to assist, should average from 60 to 70 square yards per day. The cost of the labor on 3-coat work, at about 25 cents per square yard, will be about 12 cents. For 2-coat work, at about 20 cents per square yard, the cost of the labor will be about 8 cents. Both of these figures on labor are exclusive of the cost of lathing. Where extremely fine work is demanded, these prices will be greatly increased.

The analyses of cost of 2 and 3 coat plastering, given in the complete example on estimating, are very carefully made, and may be relied on as bases for estimates.

LATHING.

39. **Lathing** is measured by the superficial yard, no openings under 7 superficial yards being deducted.

Plastering laths are about $1\frac{1}{2}$ inches wide, $\frac{1}{4}$ inch thick, and usually 4 feet long, the studding being generally placed 12 or 16 inches on centers, so that the ends of the lath may be nailed to them. The laths are usually set from $\frac{1}{4}$ to $\frac{3}{8}$ inch apart, requiring about $1\frac{3}{4}$ or $1\frac{1}{2}$ four-foot laths, respectively, to cover 1 square foot.

For a fair grade of work, a man will lay on an average about 15 bunches, or 1,500 laths, per day, while a rapid workman will put on about 2,000 laths. The cost of nailing up laths will be from 18 to 25 cents per bunch, or \$1.80 to \$2.50 per thousand, being about equal to the cost of the laths and nails.

JOINERY.

40. Joinery Details.—Joinery includes all the interior and exterior finish put in place after the framing and covering are completed; as, for example, door and window frames, doors, baseboard, paneling, wainscoting, stairs, etc. Most of these materials are worked at the mill and brought to the building ready to set in place.

Frames.—In taking off door and window frames, describe and state sizes. Measure architraves by the running foot, giving width and thickness, whether molded or plain, and state the number of plinth and corner blocks.

Sash.—State dimensions (giving the width first); thickness of the material, molded or plain; style of check-rail and sill finish; thickness of sash bar; whether plain, single or double hung; and sizes (giving dimensions in inches) and number of lights. Use standard sizes as much as possible.

Doors.—Describe and state the sizes and thickness, whether the framing is stuck-molded, raised-molded, or plain; and number of panels, whether plain or raised. Use stock sizes wherever possible and suitable.

Blinds.—Describe size and thickness; whether paneled or slatted (fixed or movable), and whether molded or plain.

Baseboard and Beam Casings.—Measure by the running foot, stating width and thickness of stuff, and whether molded or plain.

Wainscoting.—Measure by the superficial foot. State kind of finish, whether paneled or plain, and style of molding and panels. Wainscoting cap and base, measure by the running foot.

Stairways are generally taken by the contractor at so much per step, including everything complete according to the specifications. In measuring stairways, take off the amount of rough material in carriage timbers, and the

planed lumber in treads, risers, and strings. Measure balustrades by the lineal foot. Give size and style of treatment of newels. Measure spandrel and stairway paneling the same as wainscoting.

Kitchen dressers may be taken at a fixed price complete; or at a fixed rate per square foot; or as dressed lumber, drawers and doors being taken separately.

Wardrobes, bookcases, mantels, and china closets should be treated separately, and a fixed price stated.

Porches, exterior balustrades, balconies, porte cochères, etc. may be taken at a price per lineal foot, or the actual quantity of material may be measured.

DATA AND EXAMPLES OF ESTIMATING COSTS.

41. In any *molded work* which goes through the mill, the usual charge is *1 cent per square inch of section per lineal foot*, as a base, from which is deducted a percentage, generally from 40 to 60 per cent., depending on the grade of the material. For example, a $\frac{7}{8}$ -inch (undressed thickness, 1 inch) door casing, 5 inches wide, will cost $1 \text{ cent} \times 5$, less 50 per cent. = $2\frac{1}{2}$ cents per lineal foot.

Baseboard.—The cost of material and fitting in place may be estimated at 1 cent per square inch of section per lineal foot. This is for pine; if hard wood is used, double this price. The same rule applies also to chair rails, cap rails, and natural-finish picture molds.

Paneling may be estimated at 12 cents per square foot for 1-inch pine stuff; if over 1 inch, add simply for extra material. If the paneling is of hard wood and veneered, add 50 per cent. to the price of pine.

Plain *wainscoting* may be estimated at $6\frac{1}{2}$ cents per square foot, the cap being figured separately by the lineal foot.

42. Door Frames.—The following estimate represents the cost of an ordinary door frame:

COST OF DOOR FRAME IN PLACE.

Size, 2' 8" × 6' 8".

Jambs (rabbeted for doors), 13' 6"; head jamb, 3'. Total jambs, 16½' of 1½" (1¼") × 6" clear-face material, at 1 cent per sq. in., per ft., less 50 per cent.	\$0.62
Casing, 3½' of 7⁄8" (1") × 5", with ¼-round edge mold, at same rate.....	.86
Back-band molding, 34½' of 7⁄8" (1") × 2", at same rate as casing.....	.34
Plinth blocks, 4 pieces, 9" × 1¾" (2") × 5½", at 1 cent per sq. in. per ft., less 50 per cent.....	.16
Dadoing and handsmoothing casing, back band, and plinth blocks.....	.50
Nails.....	.05
Putting together and setting up (2½ hours).....	.65
Cost in place.....	\$3.18

43. Doors.—The subjoined estimate gives the cost of a door of moderate price:

COST OF DOOR IN PLACE.

Size, 2' 8" × 6' 8". 1½ in. thick, 5 panels, double face, flat paneled, and stuck or solid molded.

Door delivered.....	\$2.00
Fitting hinges and lock, hanging and trimming.....	.50
Butts, 1 pair 4 × 4, lacquered steel.....	.40
Mortise lock, brass face, and strike wood knob, bronze escutcheons.....	.80
Cost in place.....	\$3.70

Cost per square foot, 21 cents.

If the door is hard wood and veneered, add 50 per cent. to price of the above, which is for a pine door. For curved doors in curved walls, the cost is about twice that of ordinary straight work.

A fair workman can hang, trim, and put hardware, including mortise lock, on about six ordinary doors per day. For veneered doors, or those requiring extra care, not more than three can be put in place.

44. Window Frame.—The following is approximately the cost of a window frame of the size mentioned:

COST OF WINDOW FRAME IN PLACE.

Size, 2 lights, 28" × 28".

Jambs, 12'; head jamb, 3½'; total, 15½'. 15½' × 1⅛" (1¼") × 5", at 1 cent per sq. in., per ft., less 50 per cent.	\$0.48
Sill, 3½' × 1⅛" × 5⅜", same rate	.13
Subsill, 4' × 2" × 4", same rate	.16
Blind stop, 15½' × 7⁄8" × 2"	.15
Parting strip, 14½' × ½" × 1"	.04
Outside casing, 11½' × 1⅛" × 5"	.36
Head jamb, 4' × 1⅛" × 7"	.17
Cap, 4' × 1⅛" × 3"	.08
Molding, 4½' of 2½"	.06
Sill nosing, 4' × 1⅛" × 4"	.10
Apron, 4' × 7⁄8" × 5"	.10
Cove molding, 4' of 7⁄8"	.06
Casing, 16½' × 7⁄8" × 5"	.41
Back band, 16½' × 1⅛" × 1⅛"	.12
Sash stops, 14½' × ½" × 1½"	.05
Labor, for frame complete, with outside casing attached at mill, and for setting inside casing at building	1.00
Cost in place	<u>\$3.47</u>

45. Windows.—The cost of an ordinary window may be estimated as follows:

COST OF SASH IN PLACE.

Size, 2 lights, 28" × 28".

Cost of 2 sash, 1⅝" thick, at mill	\$1.15
Glass, first quality, double-thick American, and setting	1.75
Sash weights, 35 lb., at 1 cent per lb.	.35
Cord for weights, 22½', at ½ cent per ft.	.11
Sash lifts, 2	.05
Sash lock	.25
Hanging sash and putting on stops	.50
Cost in place	<u>\$4.16</u>

For curved sash in curved walls, the cost is about twice that of straight work.

46. Stairs.—The cost per step for an ordinary stairway, constructed according to the following specifications, is about \$3.00. For a better class of work, add about one-quarter to this price. Length of steps, 3 feet; tread, Georgia pine; riser, white pine; open string, white pine; nosing and cove; dovetail balusters, square or turned; rail, $2\frac{1}{2}'' \times 3''$; 6-inch start newel, cherry; two 4-inch square angle newels, with trimmed caps and pendants; simple easements, furred underneath for plastering; treads and risers tongued together, housed into wall strings, wedged, glued, and blocked.

The material of such a stairway will cost about \$1.84 per step. This rate includes landing facia and balustrade to finish on upper floor. The labor on the same, mill work and setting in place, is about \$1.16 per step. For example, for a stairs having 17 steps and landing balustrade (including return, about 14 feet), the entire cost will be $17 \times \$3.00 = \51.00 , of which \$31.28 will represent cost of dressed lumber, including turned balusters and newels, and worked rail; and \$19.72 will represent cost of labor in housing strings, cutting, mitering, and dovetailing steps, working easements, fitting and bolting rail, and erecting stairway in building.

47. Verandas.—For small dwellings, it has been found by experience that a veranda built on the following specifications will cost about \$2.25 per lineal foot: Width, 5 feet; posts, turned, set 6 or 8 feet on centers; floor timbers, $2'' \times 6''$; flooring, $\frac{7}{8}$ -inch white pine, sound grade; rafters, $2'' \times 4''$ dressed; purlins, $2'' \times 4''$, set 2 feet on centers; roof sheathing, $\frac{7}{8}$ -inch white pine; box frieze and angle mold; angle and face brackets; steps; no balustrade.

To include balustrade with 2-inch turned balusters, add about 60 cents per lineal foot.

For a veranda built according to the following specifications, the cost will be about \$4.00 per lineal foot: Width, 8 feet; columns, 9-inch, turned; box pedestals; box cornice and gutter; level ceiling; roof timbers, $2'' \times 6''$; roof covered

with matched boards; tin, a good grade; floor timbers, 2"×8"; floor, 1¼-inch white pine, second grade, with white-lead joints; no balustrade.

Including balustrade, with 2½-inch turned balusters, rail, and base to suit, add 80 cents per lineal foot.

Where a portion of the veranda is segmental or semi-circular, a close approximation to the cost will be had if the girth of the circular part is measured, and a rate fixed at twice that for straight work of the same length. This applies to veranda framing, roofing, casing, and balustrades.

HARDWARE.

48. Hardware is best estimated by noting the quantities required for each portion of the work as it is being measured, afterwards making these items into a separate hardware bill. Many of the articles, as, for example, the number of fixtures for doors or window trimmings, may be readily counted from the plans.

Hardware for windows, doors, etc. are sometimes included in estimating the cost per window, door, etc., and are not considered separately. In the estimates of such costs under "Joinery" (Arts. 43, 44, and 45), this method is followed; while in the complete example of estimating, given hereafter, the hardware is made into a separate bill.

The cost of the hardware depends entirely on the class of work and finish desired, and the best way to estimate on it is, after making the schedule, to select suitable designs and figure the prices from a catalogue.

An approximate estimate for the hardware in ordinary buildings is 1½ per cent. of the cost of the building. From 15 to 20 per cent. of the cost of hardware will pay for putting it in place.

HEATING AND VENTILATING SYSTEM.

49. Heating and ventilating work should be estimated as indicated in the following paragraphs.

Estimate all pipes and fittings same as for plumbing. Sum

up all standard radiators, and the price by square foot of radiation. Figure special radiators separately.

Itemize all valves, air vents, hangers, etc.

Estimate on pipe coverings by lineal foot.

Estimate sheet-metal indirect-radiator casings in pounds.

Estimate sheet-metal flues and smoke pipes by the lineal foot; but elbows and dampers separately.

Estimate register boxes, registers, and borders separately.

Make separate items of expansion tanks, hot-water damper regulators, and furnace regulators.

Figure heaters, steam boilers, and furnaces from manufacturer's catalogues.

In estimating on heating by furnace, the average cost of labor is about one-third that of materials. In steam and hot-water heating, the ratio is about one-fifth.

The cost of a hot-air installation is approximately 5 per cent. of the cost of the building; for steam heating, 8 per cent.; and for hot-water heating, 10 per cent.

PLUMBING AND GAS-FITTING.

50. Plumbing and gas-fitting work should be estimated as outlined in the following paragraphs:

PLUMBING.

51. An approximate figure for cost of plumbing is 10 per cent. of the cost of the building. This figure is for good materials and labor, and, of course, is subject to considerable variation. The cost of labor alone will average about one-fourth the cost of the materials.

52. Drainage System.—Measure all horizontal pipes from the plans, and vertical pipes from the sectional drawings.

Commence at the sewer outlet, and measure the main-sewer line forward into the building, and then measure the horizontal branches.

Measure the vertical, soil, waste, and vent stacks to their

terminations above the roof, and waste-pipe branches to the fixtures on the several floors.

Itemize the several pipes in the different kinds and classes.

Estimate all earthen pipe by the lineal foot, allowing for Portland cement in the joints.

Estimate all cast-iron pipe by the lineal foot, allowing for each joint $\frac{3}{4}$ pound of lead for every inch in diameter of the pipe.

Estimate wrought-iron pipe by the lineal foot, inclusive of couplings.

Estimate brass, copper, and lead pipe by the pound.

Estimate all traps, bends, branches, increasers, reducers, and other fittings separately, except such special brass fixtures, traps, and connections as are included in the cost of the fixtures. Do not figure lead bends which are smaller than 2 inches.

Estimate on brass-ferrule connections at all points where lead pipe joins iron pipe.

Estimate on all solder joints (wiped), allowing 1 pound of solder for every inch inside diameter of the pipe.

53. Water-Supply System.—For street supply, allow for permits, corporation tapping, and curb box.

Measure the service pipe from street main to cellar, and allow for a stop and waste cock, inside the cellar wall.

Measure all horizontal distributing pipes from the plans, and all vertical distributing pipes from the sectional drawings.

Measure all branches for the several fixtures on the different floors, to the lawn hydrants, etc.

Itemize the different kinds and classes of pipes.

Estimate lead, brass, and copper water pipes by the pound, and wrought-iron water pipe by the lineal foot.

Itemize all stop-cocks, pipe tacks, straps, hangers, etc. separately.

Estimate all water-pipe fittings less than $1\frac{1}{2}$ inches by the pound.

Figure on brass solder-nipple connections in all places where lead pipes join iron pipes.

Estimate on kitchen boiler, sediment cock, and range connections; and also faucets for all fixtures other than those which are included in the costs of the fixtures. .

Estimate upon garden hydrants and lawn sprinklers, and allow a stop and waste cock in cellar for each.

54. Well Supply.—Figure on double-action force pump in kitchen or laundry, if well is not deeper than 26 feet below the pump; for a deep well, estimate on pumping engine or windmill.

Measure lead tank linings in square feet, and estimate by the pound, allowing 1 pound of solder for every 2 feet of seams.

Allow 2 feet of lead pipe to connect iron pipes to house tank, and for stop-cocks close to tank.

Provide for telltale and overflow pipes for tank.

Estimate copper tanks in square feet and by the pound, allowing 1 pound for each square foot.

If there are iron, slate, glass, or cedar tanks, figure them separately.

55. Fixtures.—Estimate each fixture separately, and include traps, faucets, waste, vent, and water connections to walls or floors. When the sewer is long and has but little fall, figure on using a grease trap for the kitchen sink.

GAS-FITTING.

56. Cost.—The cost of the gas-fitting may be approximately figured as about 3 per cent. of the cost of the building. The cost of labor alone varies from about one-fourth to one-seventh of the cost of materials. The better the grade of fixtures, the lower will be the ratio—provided there is no excessive ornamentation requiring much time to put in place—as the cost of the labor is about the same for cheap fixtures as for more costly ones.

57. Estimate piping the same as for plumbing.

Allow for meter, permits, tapping gas main, etc.

Figure each gas fixture separately set up in place. Owner

usually makes a selection of fixtures from manufacturer's catalogue. Allow for shields, fire-guards, etc., in places where there is danger of fire.

Figure gas grates, gas stoves, gas heaters, etc. separately. Where the gas pressure is very high or unsteady, allow for a pressure regulator.

PAINTING AND PAPERING.

PAINTING.

58. Painting is measured by the superficial yard, girting every part of the work that is covered by paint, and allowing additions to the actual surface to compensate for the difficulty of covering deep quirks of moldings, for carved and enriched surfaces, etc. Ordinary door and window openings are usually measured solid, to compensate for the extra time taken in working around them, "cutting in" the window sash, etc. Porch and stair balustrades, iron railings, and work having numerous thin strips, are also counted solid, for a like reason. Allowance is frequently made for distance from ground that the work is to be done, as in cornices, balconies, dormers, etc., and also for the difficulty of access.

Charges are usually made for each coat of paint put on, at a certain price per superficial yard and per coat.

Graining and marbling (imitations of wood and stone) and varnishing are rated at different prices from plain work.

Capitals and columns and other ornamental work which are difficult to measure should be enumerated, and a clear description of the amount of work on them should be given.

DATA ON PAINTING.

59. Quantities.—One pound of paint will cover from $3\frac{1}{2}$ to 4 square yards of wood for the first coat, and from $4\frac{1}{2}$ to 6 square yards for each additional coat; on brickwork, it will cover about 3 and 4 square yards, respectively. Colored paint will cover about one-third more surface than white paint.

Using prepared or ready-mixed paint, 1 gallon will cover from 250 to 300 square feet of wood surface, two coats; for covering metallic surfaces, 1 gallon will be sufficient for from 300 to 350 square feet, one coat. The weight per gallon of mixed paints varies considerably, but, on an average, may be taken at about 16 pounds.

Prepared shingle stains will cover about 200 square feet of surface per gallon, if applied with a brush; or this quantity will be sufficient for dipping about 500 shingles. Rough-sawed shingles will require about 50 per cent. more stain than smooth ones.

One pound of *cold-water* paint will cover from 50 to 75 square feet for first coat, on wood, according to surface condition, and about 40 square feet of brick and stone.

One gallon of liquid pigment filler, hard-oil finish, or varnish generally will cover from 350 to 450 square feet of surface for first coat, according to nature of wood and finish; and from 450 to 550 square feet for the second and subsequent coats. Ten pounds of paste wood filler will cover about 400 square feet.

One gallon of varnish weighs from 8 to 9 pounds; turpentine, about 7 pounds; and boiled or raw linseed oil, about $7\frac{3}{4}$ pounds.

For puttying, about 5 pounds will be sufficient for 100 square yards of interior and exterior work.

For sizing, about $\frac{1}{2}$ pound of glue is used to 1 gallon of water.

For mixing paints, the following figures represent the average proportions of materials required per hundred pounds of lead:

QUANTITIES OF MATERIALS.

Coat.	Lead. Pounds.	Raw Oil. Gal.	Japan Drier. Gal.
Priming	100	7	$\frac{3}{4}$
Second	100	6	..
Third	100	$6\frac{1}{2}$ -7	..

The drier is omitted in the second and succeeding coats, unless the work is to be dried very rapidly, as it is considered to be injurious to the durability of the paint.

On outside work, boiled oil is generally used in about the proportion of 3 gallons to 2 gallons of raw oil.

60. Cost.—The cost of applying paint, on general interior and exterior work, will average about twice the cost of the materials; while for very plain work, done in one color, the cost may be taken at about $1\frac{1}{2}$ times that of the materials. For stippling, the cost will be about the same as for two coats of paint. For varnishing, the cost of labor will be about $1\frac{1}{2}$ times the price of the varnish.

The following figures represent fair average prices, for various classes of work, and have been adopted by the Builders' Exchange of a large eastern city:

INTERIOR WORK.

	Cost per Square Yard.
1 coat paint, 1 color.....	12 cents
1 coat paint, 2 colors.....	15 cents
2 coats paint, 2 colors.....	20 cents
3 coats paint, 2 colors.....	25 cents
2 coats paint, 3 colors.....	25 cents
3 coats paint, 3 colors.....	32 cents
1 coat shellac.....	10 cents
Walls, 1 coat size, 2 coats paint.....	20 cents
Walls, 1 coat size, 3 coats paint stipple.....	30 cents

HARD-WOOD FINISH.

1 coat paste filler, 1 coat varnish.....	30 cents
1 coat paste filler, 2 coats varnish.....	40 cents
1 coat paste filler, 3 coats varnish.....	50 cents

NATURAL FINISH.

1 coat liquid filler, 1 coat varnish.....	20 cents
1 coat liquid filler, 2 coats varnish.....	25 cents
1 coat liquid filler, 3 coats varnish, rubbed.....	40 cents
Floors: filling, shellacking, varnishing, or waxing, 2 coats.....	35 cents

TINTING WALLS.

*Distemper Color.*Cost per
Square Yard.

Tinting, 50 yards or less.....	9 cents
Tinting, 50 yards or more.....	7 cents
Patching and washing walls.....	7 cents

EXTERIOR PAINTING.

WOODWORK.

1 coat, new work.....	10 cents
2 coats, new work, 2 colors.....	18 cents
2 coats, new work, 3 colors.....	20 cents
3 coats, new work, 2 colors.....	25 cents
3 coats, new work, 3 colors.....	28 cents

BRICKWORK.

1 coat.....	12 cents
2 coats.....	18 cents
3 coats.....	25 cents

SANDING.

2 coats paint, 1 coat sand.....	28 cents
3 coats paint, 1 coat sand.....	35 cents
3 coats paint, 2 coats sand.....	50 cents

MISCELLANEOUS.

Dipping shingles, per 1,000.....	\$3.00
Additional coat, per 1,000.....	.50
Blinds, per foot, 1 coat.....	.08
Fence, per foot, 1 coat, 4 feet high, wood.....	.12
Iron fence, per foot, 1 coat.....	.08
Tin roof, per yard, 1 coat.....	.05

PAPERING.

61. Papering is usually figured per roll, put on the wall. The paper is generally 18 inches wide, and is in 16-yard rolls. On account of waste in matching, etc., it is difficult to estimate very closely the number of rolls required, but an approximate result may be obtained as follows: Divide the perimeter of the room by $1\frac{1}{2}$ (the width of paper in feet):

the result will be the number of strips. Find the number of strips which can be cut from a roll, and divide the first result by the second; the quotient will be the number of rolls required. No openings less than 20 square feet in area should be deducted, in order to compensate for cutting and fitting at such places. Add about 15 per cent. to the area to allow for waste. The border, whether wide or narrow, is generally figured as 1 roll of paper.

The cost of paper is extremely variable, ranging from 15 cents to \$6.00 per double roll; the average cost is probably 25 to 50 cents per roll, for ordinary houses. Paper hanging costs from 30 to 75 cents per double roll, with strips butted, the former figure being for the usual grade of work; with lapped strips, the cost is less, being from 20 to 25 cents per roll. Usually an extra charge is made for papering ceilings.

GLAZING.

62. Formerly glazing was included in the painter's contract, but as it is now usual and more convenient to glaze the sash at the mill when they are made, the glazing is included in the joinery specifications, and is not considered as a separate subdivision of estimating work. This method is followed in the example given hereafter.

In measuring glass, take the dimensions between rabbets each way, when the panes are rectangular; if irregular or circular in form, take the extreme dimensions, and consider the panes rectangular.

Polished plate glass is largely used for store-front windows, and also for glazing window sash in fine work. There are three qualities: French plate, and two grades of American plate, which may be obtained in panes varying in size from 1 inch square to 8 feet wide and 14 feet long. The cost of plate glass is estimated by the aid of a price list which gives the cost of the various sizes. This list remains the same from year to year, and is known as the standard list; the fluctuations are provided for by means of a discount, which is the same for all sizes of glass.

PANES OF WINDOW GLASS PER BOX.

Size. Inches.	Panes in Box.	Size. Inches.	Panes in Box.	Size. Inches.	Panes in Box.	Size. Inches.	Panes in Box.
6 × 8	150	12 × 19	32	16 × 20	23	24 × 44	7
7 × 9	115	12 × 20	30	16 × 22	20	24 × 50	6
8 × 10	90	12 × 21	29	16 × 24	19	24 × 56	5
8 × 11	82	12 × 22	27	16 × 30	15	26 × 36	8
8 × 12	75	12 × 23	26	16 × 36	12	26 × 40	7
9 × 10	80	12 × 24	25	16 × 40	11	26 × 48	6
9 × 11	72	13 × 14	40	18 × 20	20	26 × 54	5
9 × 12	67	13 × 15	37	18 × 22	18	28 × 34	8
9 × 13	62	13 × 16	35	18 × 24	17	28 × 40	6
9 × 14	57	13 × 17	33	18 × 26	15	28 × 46	6
9 × 15	53	13 × 18	31	18 × 34	12	28 × 50	5
9 × 16	50	13 × 19	29	18 × 36	11	30 × 40	6
10 × 10	72	13 × 20	28	18 × 40	10	30 × 44	4
10 × 12	60	13 × 21	26	18 × 44	9	30 × 48	5
10 × 13	55	13 × 22	25	20 × 22	16	30 × 54	5
10 × 14	52	13 × 24	23	20 × 24	15	32 × 42	5
10 × 15	48	14 × 15	34	20 × 25	14	32 × 44	5
10 × 16	45	14 × 16	32	20 × 26	14	32 × 46	5
10 × 17	42	14 × 18	29	20 × 28	13	32 × 48	5
10 × 18	40	14 × 19	27	20 × 30	12	32 × 50	4
11 × 11	59	14 × 20	26	20 × 34	11	32 × 54	4
11 × 12	55	14 × 22	23	20 × 36	10	32 × 56	4
11 × 13	50	14 × 24	22	20 × 40	9	32 × 60	4
11 × 14	47	14 × 28	18	20 × 44	8	34 × 40	5
11 × 15	44	14 × 32	16	20 × 50	7	34 × 44	5
11 × 16	41	14 × 36	14	22 × 24	14	34 × 46	5
11 × 17	39	14 × 40	13	22 × 26	13	34 × 50	4
11 × 18	36	15 × 16	30	22 × 28	12	34 × 52	4
12 × 12	50	15 × 18	27	22 × 36	9	34 × 56	4
12 × 13	46	15 × 20	24	22 × 40	8	36 × 44	5
12 × 14	43	15 × 22	22	22 × 50	7	36 × 50	4
12 × 15	40	15 × 24	20	24 × 28	11	36 × 56	4
12 × 16	38	15 × 30	16	24 × 30	10	36 × 60	3
12 × 17	35	15 × 32	15	24 × 32	9	36 × 64	3
12 × 18	33	16 × 18	25	24 × 36	8	40 × 60	3

When stained or art glass is used, the specifications generally limit the cost, as the glass is made according to the architect's designs.

Ordinary window or sheet glass is sold by the box, which contains, as nearly as possible, 50 square feet, whatever the size of the glass may be. There are two qualities of ordinary glass, known as *single* and *double thick*, the former being about $\frac{1}{16}$ inch thick, and the latter nearly $\frac{1}{8}$ inch. Single-thick glass should never be used in panes over 24 in. $\times$ 24 in. in size.

The foregoing table gives the number of panes of window glass in one box of 50 square feet.

EXAMPLE IN ESTIMATING.

63. Following the rules and suggestions already given in this section, the estimate for a house will be made as a practical example, the drawings on which it is based being shown in the accompanying plates. In making the estimate, the various portions of the work are taken in the order in which they naturally occur in the erection of the building, following, as closely as may be, the estimating schedule heretofore given.

The student is expected to take off the quantities and perform all the indicated work for himself, as far as possible, checking up the figures given in the example. It is only by actually making the calculations that he will derive any practical benefit from the work.

No two estimators, working separately, will arrive at exactly the same results; and the student, in following the calculations in this example, will doubtless find some discrepancies between his figures and the ones given. These should not be important ones, however, and by carefully studying the methods followed, he should obtain substantially the same results as those computed herein.

EXCAVATION.

64. In calculating the number of cubic yards of earth to be excavated for the cellar, all the measurements are taken from the foundation plan and the sections. The method

pursued in making calculations is as follows: The plan is blocked out as shown in the accompanying "Cellar Plan," and the area of each block is determined; then, by multiplying the sum of these partial areas by the depth of the cellar, the cubic contents are determined. The trenches for the foundation walls of porches and for the footings of cellar walls are calculated separately, as also are the excavations for piers, drains, cesspools, area, etc.

QUANTITIES.

CELLAR EXCAVATION.

	Sq. Ft.	Cu. Ft.
Block <i>A</i> , 23' 4" × 16' 4"	381.0	
Block <i>B</i> , 14' 6" × 20' 10".....	302.0	
Add for projection of wall, $\frac{13' + 7'}{2} \times 3' =$	30.0	
	332.0	
Block <i>C</i> , 27' 6" × 17' 5"	479.0	
Deduct for breaks in wall, 1' 7" × 6' 8" and 2' 6" × 3'... ..	18.0	
	461.0	
Block <i>D</i> , 26' 6" × 10' 5½"	277.2	
Block <i>E</i> , 16' 8" × 11' 6½"	192.4	
Deduct for breaks in wall, 6' 6" × 1' 11" and 3' × 5"....	13.7	
	178.7	
Block <i>F</i> , 9' 10" × 9' 7½" ÷ 2.....	47.3	
Block <i>G</i> , 14' × 14' × .7854 ÷ 2.....	77.0	
Deduct for portion of semi-circular part, included in <i>F</i> , 12" × 14'.....	14.0	
	63.0	
Total area of excavation.....	1,740.2	
Contents, 1,740.2 sq. ft. × 6.5 ft. (depth)		11,311.3

EXCAVATION FOR WALL FOOTINGS.
Lengths scaled along center line of walls:

	Sq. Ft.	Cu. Ft.
<i>a b</i> , 26' $\times$ 2' 6"	65.0	
<i>b c</i> , 5' 6" $\times$ 3'	16.5	
<i>c d</i> , 9' 9" $\times$ 2' 6"	24.4	
<i>d e</i> , 17' 6" $\times$ 2' 6"	43.7	
<i>e f</i> , 26' 4" $\times$ 2' 6"	65.8	
<i>f g</i> , 9' $\times$ 3' 8"	33.0	
<i>g h</i> , 19' 9" $\times$ 2' 6"	49.4	
<i>i j</i> , 27' 7" $\times$ 2' 6"	69.0	
<i>j a</i> , 31' $\times$ 2' 6"	77.5	
<i>k l</i> (less openings), 18' 9" $\times$ 2' 6"	46.9	
Chimney, 12' 6" $\times$ 4' (approximately) 50		
Deductions..... 10.4	39.6	
<i>m n</i> (less openings), 7' 9" $\times$ 2' 6"	19.4	
<i>o p</i> , 19' 6" $\times$ 1' 9"	34.1	
Total area of excavation for footings ..	584.3	
Contents, 584.3 sq. ft. $\times$ 10 in. (.833 ft.)		
depth.....		486.7

MISCELLANEOUS EXCAVATIONS.
Lengths scaled along center line of walls:

	Cu. Ft.
Front porch, 69' 9" $\times$ 2' 3" $\times$ 3'	470.8
Back porch, 24' 6" $\times$ 2' $\times$ 3'	147.0
Piers for steps, 1' 9" $\times$ 2' $\times$ 3' $\times$ 4'	42.0
Piers for kitchen porch, 2' $\times$ 2' $\times$ 3' $\times$ 2'	24.0
Cellar area, 5' 9" $\times$ 6' $\times$ 6' 6"	224.2
Deduct 1' 9" $\times$ 3' $\times$ 6' 6"	34.1
Dry cesspool, 6 ft. diameter $\times$ 6 ft. depth.....	169.6
Cesspool, 6 ft. diameter $\times$ 8 ft. depth.....	226.2
Trench for pipe to cesspool, 25' $\times$ 7' 6" $\times$ 2'	375.0
Trench for drain pipes (roof drainage), 228' $\times$ 3' $\times$ 1'	684.0
Trench for drain pipes from junction to dry cesspool, 20' $\times$ 3' $\times$ 18"	90.0
Total.....	2,418.7
Grand total of excavation	14,216.7

FILLING.

	Cu. Ft.
Around foundation walls, $178' 6'' \times 6'' \times 6' 6''$	594.8
Around foundation of porches, $102' \times 6'' \times 3'$	153.0
Total filling.....	747.8

COST.

The cost of excavation is based on the following analysis:

Cost of 1 Cubic Yard of Excavation.

	Cents.
One man can pick 15 cu. yd. per day; wages being \$1.50, one yard will cost.....	10
One man can throw out 15 cu. yd. per day; wages being \$1.50, one yard will cost.....	10
One man with horse and cart can haul on a short haul 20 cu. yd. per day; wages being \$2.50, one yard will cost.....	12½
Cost per cubic yard.....	32½

The cost of filling, including tamping, may be taken as about one-third that of excavation, or, say, 11 cents per cu. yd.

Summary.

Excavation, 14,216.7 cu. ft. = 526.5 cu. yd., at 32½ cents per cu. yd.....	\$171.11
Filling, 747.8 cu. ft. = 27.7 cu. yd., at 11 cents per cu. yd.....	3.05
Total cost of excavation and filling.....	\$174.16

STONEMWORK.

65. The foundation walls are built of rubble masonry to the sill at the grade line, and from this sill to the water-table they are built of ashlar with rubble backing, excepting those

portions behind porches which are wholly rubble. The estimate for stonework also includes the concrete for footings and cellar floor; the number of cubic feet of concrete required for the footings will be found by referring to the item "Excavation for Footings."

RUBBLE MASONRY.

Quantities.

(External measurements with no deduction for openings.)

	Cu. Ft.
Cellar walls, $178' 6'' \times 1' 6'' \times 6' 6''$	1,740.4
Add for extra thickness over $1' 6''$:	
$5'' \times 6' \times 6' 6''$	16.3
$1' 2'' \times 10' 6'' \times 6' 6''$	<u>79.6</u>
	95.9
* Foundation walls for front porch:	
$74' 6'' \times 1' 4'' \times$ (average thickness) $2' 6''$	247.7
Foundation for steps:	
2 piers, $1' 6''$ square $\times 2' 6''$	11.2
2 piers, $2'$ square $\times 2' 6''$	<u>20.0</u>
	31.2
Stone footings, under porch foundations, $74' 6''$ $\times 2' 3'' \times 6''$	83.8
Backing for ashlar and water-table (see "Ashlar"), $78' \times 1' \times 3'$	234.0
Rubble wall behind porches, $99' 4'' \times 1' 6'' \times 3'$	447.0
* Foundation walls rear porch, $27' \times 1' 6'' \times 2' 6''$	101.2
Footings, walls rear porch, $27' \times 2' 3'' \times 6''$	30.4
Area walls, $13' 6'' \times 12'' \times 6' 6''$	87.7
Stone footing for area walls, $13' 6'' \times 18'' \times 6''$	10.1
Piers, $18'' \times 18'' \times 2' 6'' \times 2$	<u>11.3</u>
Total rubble masonry	3,120.7

* Although these are made continuous, to carry the base, or ground sill, independent piers under the porch columns might be substituted, at a somewhat less cost.

Cost.

The estimate of cost of the rubble masonry is based on the following analysis:

Cost of 1 Perch of Rubble Masonry.

1 man can lay 3 perches per day; wages being \$2.50 per day, 1 perch will cost.....	\$0.83
3 laborers are required for 4 masons; wages being \$1.50 per day, 1 perch will cost.....	.38
Stone, delivered at work.....	1.25
$\frac{1}{6}$ load sand, at \$1.50 per load.....	.25
$\frac{1}{2}$ barrel Rosendale cement, at \$1.25 per bbl.....	.63
Total cost of 1 perch.....	\$3.34

Summary.

From the foregoing calculation, the quantity of rubble masonry is 3,120.7 cu. ft. Taking 25 cu. ft. to 1 perch, $3,120.7 \div 25 = 124.8$ perches, which at \$3.34 per perch makes the total cost of rubble masonry..... \$416.83

ASHLAR.

The walls between base sill and water-table are faced with ashlar, which extends around main walls to porches, and all porch piers are built of ashlar.

Quantities.

	Sq. Ft.
Facing for cellar walls, 78 lineal ft. $\times$ 2 ft. 3 in.	175.5
Porch piers, $29\frac{1}{4}$ lineal ft. $\times$ 2 ft. 3 in.	65.8
Total ashlar.....	241.3

Cost.

The estimated cost of ashlar is based on the following analysis:

Cost of 1 Square Foot of Ashlar.

Cost of stone, bluestone facing.....	\$0.30
Hauling stone, say $\frac{1}{10}$ of cost of stone.....	.03
Mortar.....	.01
Labor, estimating 80 sq. ft. per day for 2 masons and 1 laborer:	
2 masons, at \$3 per day.....	.075
1 laborer, at \$1.50 per day.....	.02
Cost per square foot.....	<u>\$0.44</u>

Summary.

From the foregoing quantities, the ashlar amounts to 241.3 square feet, which, at 44 cents per square foot, will make the total cost of ashlar. \$106.17

CUT STONE.

Quantities and Cost.

	Cost per Ft.	Total Cost.
Base, or ground sill, extending under porches (except under stone steps) and along exposed main walls, 172 ft., 5" × 11" and 6" × 8" dressed and chamfered sandstone.....	\$0.60	\$103.20
Water-table, extending around main walls, 178 ft. 6 in., 6" × 10" dressed and chamfered sandstone.....	.60	107.10
Lintel course, extending over brick walls, 125 lineal ft., 6" × 10" dressed sand- stone.....	.60	75.00
12 dressed sandstone window sills, cut with lug and drip, 5" × 8", 55 $\frac{3}{4}$ lineal ft.....	.60	33.45

	Cost per Ft.	Total Cost.
Cut-stone jambs for main door, 10"×10",		
19½ lineal ft.....	\$1.75	\$34.13
1 door sill, 6"×10", 5¾ lineal ft.....	1.00	5.75
Coping on area walls, 3"×16", 12 lineal		
ft	.60	7.20
Porch steps, 8"×12", 57 lineal ft., dressed		
sandstone	1.25	71.25
9 bluestone steps, for outside cellar en-		
trance, 4'×12"×2"	.25	9.00
Bluestone lintel for kitchen fireplace,		
6'×12"×6"	1.00	6.00
Cut stone for main chimney		15.00
Labor, setting lintels, sills, etc.:		
1 mason, 8 days, at \$3.00 per day.....		24.00
2 laborers, 8 days each, at \$1.50 per day.		24.00
Total cost of cut stone.....		\$515.08

CONCRETE FOOTINGS AND FLOOR.

Quantities.

Footings, as per "Excavation for	
Footings," 486.7 cu. ft. ÷ 27.....	18.3 cu. yd
Concrete floor:	Sq. Ft.
Area of cellar excavation.....	1,740.2
Deduct area of footings.....	584.3
	<u>1,155.9</u>
Add for 6-inch strip over inner	
projection of wall footings,	
165'×6"	82.5
Add for projection on both sides	
of interior walls, 79'×6".....	38.5
Add for projection over chimney	
footing, 31' 6".....	15.5
Total area of concrete floor, 1,292.4 = 143.6 sq. yd.	

Cost.

The estimates for concrete footings and floor are based on the following analyses of costs:

Cost of 1 Cubic Yard of Concrete.

1 barrel of Rosendale cement	\$1.25
3 barrels of sand, or $\frac{1}{3}$ load, at \$1.50 per load.....	.50
1 cu. yd. (about 6 barrels) of broken stone	1.50
Mason, $\frac{1}{4}$ day, at \$2.50.....	.62
Laborer, 1 day, at \$1.50.....	1.50
Total.....	\$5.37

Cost of 1 Square Yard of Cellar Floor.

Concrete, $4\frac{1}{2}$ inches thick, at \$5.37 per cubic yard....	\$0.67
Sand bed, 6 inches thick, approximately 1 barrel....	.17
Spreading sand.....	.03
$\frac{1}{2}$ barrel of Portland cement for $\frac{1}{2}$ -inch finishing coat, at \$2.60 per barrel.....	.21
$\frac{1}{2}$ barrel of white sand, at \$1.00 per barrel.....	.08
Mixing and spreading surface layer.....	.08
Cost per square yard.....	\$1.24

Summary.

Footing concrete, as per foregoing figures, 18.3 cu. yd. at \$5.37 per cu. yd.....	\$98.27
Concrete floor, 143.6 sq. yd. at \$1.24 per sq. yd...	178.06
Total cost of concrete.....	\$276.33

RECAPITULATION OF COST OF STONEMWORK.

Rubble masonry.....	\$416.83
Ashlar masonry.....	106.17
Cut stone.....	515.08
Concrete footings and floor.....	276.33
Total cost of stonework.....	\$1,314.41

BRICKWORK.

66. In estimating the brickwork, openings have been deducted, thus practically giving "kiln count," so that the analyses of prices given heretofore will apply. If openings had not been deducted, the prices would have been decreased 15 per cent., as before noted.

PRESSED BRICK.

Quantities.		No. Brick.
Facing exterior walls, same length as stone lintel course, $125' \times 8' 9'' = 1,093.8$ sq. ft., at $7\frac{1}{2}$ bricks per sq. ft.....		8,203
Deduct for openings:	Sq. Ft.	
9 windows, total width $32' \times 6' 6''$ high...	208.0	
2 casement windows, total width $7' 4'' \times 8'$ high.....	58.7	
1 lavatory window, total width $2' 6'' \times 5' 6''$	13.7	
Main door, $3' 5'' \times 8' 6''$	29.1	
Total deductions.....	309.5	
$309.5 \times 7\frac{1}{2} =$		2,321
No. of brick.....		5,882
Add 5 per cent. for waste.....		294
Total pressed brick.....		6,176

Cost.

The cost of pressed brickwork is based on the following analysis:

Cost of 1,000 Pressed Brick in Place.

	Cost per M.
1,000 pressed bricks, delivered.....	\$30.00
1 bricklayer can lay 300 pressed brick per day of 9 hours, or 1,000 will require 30 hours; wages being 40 cents per hour.....	12.00
1 laborer to 2 men, 15 hours, at 15 cents per hour ..	2.25
$\frac{1}{2}$ barrel of lime.....	.38
$\frac{1}{4}$ load of sand.....	.37
Total.....	\$45.00

Summary.

From the preceding estimate of quantities, the number of pressed brick laid is 5,882, which, at \$45.00 per M, will cost	\$264.69
Pressed brick, not laid, 294, at \$30.00 per M.....	8.82
Total cost of pressed brickwork.....	\$273.51

COMMON BRICK.

Quantities.	No. Brick.
Backing exterior pressed-brick walls, $8\frac{1}{2}$ " thick, 5,882 $\times$ 2 =	11,764
Interior cellar walls, $28' \times 8' = 224$ sq. ft. (17-inch wall) at 30 brick per sq. ft.....	6,720
Deduct for 3 openings, $12' 6"$ total width $\times 6' 6"$ height = $81\frac{1}{4}$ sq. ft. at 30 brick per sq. ft.....	2,437
Interior wall, $8\frac{1}{2}$ " thick, $19' 9" \times 8'$, 158 sq. ft. at 15 brick per sq. ft.....	2,370
Chimney, principal (flues figured solid), approxi- mately 920 cu. ft., at $22\frac{1}{2}$ brick per sq. ft.....	20,700
Chimney, rear, approximately 245 cu. ft., at $22\frac{1}{2}$ brick per sq. ft.....	5,512.5
Trap pits, 46 sq. ft., at $7\frac{1}{2}$ brick per sq. ft.....	345
	44,974
Add 5 per cent. for waste.....	2,249
	47,223

Cost.

The cost of the common brickwork is based on the following analysis:

Cost of 1,000 Common Brick in Place.

	Cost per M.
1,000 brick, delivered.....	\$6.00
1 bricklayer can lay 1,000 brick in 7 hours; wages being 35 cents per hour, the cost of laying 1,000 is	2.45
1 helper, 7 hours, at 15 cents per hour.....	1.05
3 bushels of lime, at 25 cents per bushel.....	.75
$\frac{1}{2}$ load of sand, at \$1.50 per load.....	.75
Total.....	\$11.00

Summary.

According to the estimate of quantities, the number of common brick laid is 44,974, which, at \$11.00, will cost..... \$494.71

Common bricks, not laid, 2,249, at \$6.00.....	13.49
Molded brick and terra-cotta cap for rear chimney.	10.00
Total cost of common brickwork.....	\$518.20

RECAPITULATION OF COST OF BRICKWORK.

Pressed brickwork.....	\$273.51
Common brickwork.....	518.20
Total cost of brickwork.....	\$791.71

CARPENTRY.

FRAMING.

67. In estimating carpentry work, it is advisable to make a tabulated list of the various sizes of joists, rafters, etc., giving the number and dimensions of each set. Thus any error in calculation or change in price can be corrected with little difficulty.

Quantities.

Floor Framing, First Story.

	Lineal Ft.	Ft. B. M
Joists, 3"×10"; 2½ ft. B. M., per lineal ft.:		
6 pieces, each 14' 6"	87.00	
2 pieces, each 15' 3"	30.50	
1 piece, 16' 3"	16.25	
5 pieces, each 17' 6"	87.50	
1 piece, 12' 6"	12.50	
6 pieces, each 11' 0"	66.00	
1 piece, 9' 6"	9.50	
18 pieces, each 14' 0"	252.00	
1 piece, 11' 6"	11.50	
3 pieces, each 10' 6"	31.50	
1 piece, 9' 4"	9.33	

	Lineal Ft.	Ft. B. M.
6 pieces, each 24' 0"	144.00	
1 piece, 11' 4"	11.33	
2 pieces, each 20' 6"	41.00	
6 pieces, each 20' 0"	120.00	
4 pieces, each 21' 0"	84.00	
2 pieces, each 7' 0"	14.00	
2 pieces, each 13' 0"	26.00	
1 piece, 10' 0"	10.00	
Total	1,063.91	2,659.78

Floor Framing, Second Story.

	Lineal Ft.	Ft. B. M.
Girder, 6"×12"; 6 ft. B. M., per lineal ft.:		
1 piece, 8' 9"	8.75	52.50
Joists, 2"×10"; 1½ ft. B. M., per lineal ft.:		
15 pieces, each 14' 0"	210.00	
2 pieces, each 15' 6"	31.00	
5 pieces, each 17' 0"	85.00	
3 pieces, each 15' 0"	45.00	
14 pieces, each 16' 0"	224.00	
2 pieces, each 7' 0"	14.00	
2 pieces, each 10' 0"	20.00	
4 pieces, each 11' 0"	44.00	
7 pieces, each 24' 0"	168.00	
3 pieces, each 20' 6"	61.50	
4 pieces, each 12' 6"	50.00	
2 pieces, each 13' 6"	27.00	
Total	979.50	1,632.50
Joists, 3"×10"; 2½ ft. B. M., per lineal ft.:		
(Headers) 2 pieces, each 8' 9"	17.50	
2 pieces, each 6' 0"	12.00	
5 pieces, each 9' 9"	48.75	
11 pieces, each 19' 6"	214.50	
	292.75	731.87

Floor Framing, Attic.

	Lineal Ft.	Ft. B. M.
Joists, 2"×10"; 1½ ft. B. M., per lineal ft.:		
15 pieces, each 14' 0"	210.00	
2 pieces, each 15' 6"	31.00	
5 pieces, each 17' 0"	85.00	
3 pieces, each 15' 0"	45.00	
14 pieces, each 16' 0"	224.00	
2 pieces, each 7' 0"	14.00	
2 pieces, each 10' 0"	20.00	
4 pieces, each 11' 0"	44.00	
7 pieces, each 24' 0"	168.00	
3 pieces, each 20' 6"	61.50	
4 pieces, each 12' 6"	50.00	
2 pieces, each 13' 6"	27.00	
Total.....	979.50	1,632.50

Joists, 3"×10"; 2½ ft. B. M., per lineal ft.:		
2 pieces, each 8' 9"	17.50	
2 pieces, each 6' 0"	12.00	
5 pieces, each 9' 9"	48.75	
11 pieces, each 19' 6"	214.50	
Total.....	292.75	731.87

Floor Framing, Front Porch.

	Lineal Ft.	Ft. B. M.
Joists, 3"×9"; 2¼ ft. B. M., per lineal ft.:		
3 pieces, each 7' 0"	21.00	
1 piece, 6' 9"	6.75	
2 pieces, each 10' 0"	20.00	
1 piece, 8' 6"	8.50	
Total.....	56.25	126.56

	Lineal Ft.	Ft. B. M.
Joists, 2"×6"; 1 ft. B. M., per lineal ft.:		
2 pieces, each 21' 6".....	43.00	
2 pieces, each 19' 3".....	38.50	
4 pieces, each 8' 0".....	32.00	
1 piece, 10' 3".....	10.25	
6 pieces, each 9' 0".....	54.00	
2 pieces, each 4' 6".....	9.00	
5 pieces, each 6' 0".....	30.00	
4 pieces, each 5' 0".....	20.00	
3 pieces, each 2' 0".....	6.00	
3 pieces, each 9' 0".....	27.00	
Total.....	269.75	269.75

Floor Framing, Back Porches.

	Lineal Ft.	Ft. B. M.
Joists, 2"×6"; 1 ft. B. M., per lineal ft.:		
2 pieces, each 21' 0".....	42.00	
3 pieces, each 8' 0".....	24.00	
Total.....	66.00	66.00

Joists, 3"×6"; 1½ ft. B. M., per lineal ft.:		
5 pieces, each 5' 9".....	28.75	
12 pieces, each 6' 9".....	81.00	
1 piece, 8' 6".....	8.50	
2 pieces, each 3' 6".....	7.00	
Total.....	125.25	187.87

Bridging.

	Lineal Ft.	Ft. B. M.
2"×4"; ¾ ft. B. M., per lineal ft.:		
First floor, 170 pieces, each 1' 6"...	255.00	
Second floor, 138 pieces, each 1' 6"...	207.00	
Third floor, 138 pieces, each 1' 6"...	207.00	
Total.....	669.00	446.00

Main Roof Framing.

	Lineal Ft.	Ft. B. M.
Rafters, 2"×6"; 1 ft. B. M., per lineal ft.:		
15 pieces, each 20' 0"	300.00	
14 pieces, each 19' 3"	269.50	
1 piece, 18' 0"	18.00	
2 pieces, each 16' 0"	32.00	
2 pieces, each 14' 0"	28.00	
1 piece, 13' 4"	13.33	
3 pieces, each 10' 6"	31.50	
3 pieces, each 8' 6"	25.50	
1 piece, 6' 9"	6.75	
3 pieces, each 5' 0"	15.00	
3 pieces, each 3' 0"	9.00	
4 pieces, each 17' 0"	68.00	
1 piece, 12' 6"	12.50	
1 piece, 10' 9"	10.75	
2 pieces, each 9' 0"	18.00	
1 piece, 7' 0"	7.00	
18 pieces, each 9' 6"	171.00	
2 pieces, each 13' 0"	26.00	
2 pieces, each 7' 9"	15.50	
2 pieces, each 6' 6"	13.00	
4 pieces, each 3' 6"	14.00	
2 pieces, each 2' 0"	4.00	
4 pieces, each 8' 0"	32.00	
2 pieces, each 11' 0"	22.00	
8 pieces, each 5' 3"	42.00	
1 piece, 6' 0"	6.00	
8 pieces, each 11' 0"	88.00	
Total	1,298.33	1,298.33
Valley rafter, 3"×10"; 2½ ft. B. M., per lineal ft.:		
1 piece, 24' 6"		61.25
Ridge plates, 2"×10"; 1½ ft. B. M., per lineal ft.:		

	Lineal Ft.	Ft. B. M.
1 piece, 23' 6".....	23.50	
1 piece, 29' 3".....	29.25	
1 piece, 9' 0".....	9.00	
Total	61.75	102.92
Plates, 3"×6"; 1½ ft. B. M., per lineal ft.:		
4 pieces, each 10' 6"		63.00
Octagonal post, 6"×6"×3'		9.00

Porch-Roof Framing.

	Lineal Ft.	Ft. B. M.
Rafters, 2"×6"; 1 ft. B. M., per lineal ft.:		
2 pieces, each 9' 6".....	19.00	
22 pieces, each 8' 6".....	187.00	
4 pieces, each 6' 6".....	26.00	
8 pieces, each 7' 0".....	56.00	
2 pieces, each 11' 0".....	22.00	
Total.....	310.00	310.00
Rafters, 2"×5"; ½ ft. B. M., per lineal ft.:		
27 pieces, each 8' 0".....	216.00	
8 pieces, each 6' 6".....	52.00	
2 pieces, each 10' 6".....	21.00	
2 pieces, each 3' 0".....	6.00	
2 pieces, each 3' 6".....	7.00	
Total.....	302.00	251.65
Plate, 5"×10"; 4½ ft. B. M., per lineal ft.:		
5 pieces, each 15' 0"	75.00	312.50
Sills, 3"×5"; 1½ ft. B. M., per lineal ft.:		
2 pieces, each 10' 0".....	20.00	
5 pieces, each 9' 0".....	45.00	
Total.....	65.00	81.25

Wall Studding.

	Lineal Ft.	Ft. B. M.
Wall plates, 4"×11"; $3\frac{2}{3}$ ft. B. M., per lineal ft.:		
10 pieces, each 18' 0"	180.00	660.00
Studs, 2"×5"; $\frac{5}{8}$ ft. B. M., per lineal ft.:		
63 pieces, each 21' 0"	1,323.00	
106 pieces, each 12' 0"	1,272.00	
20 pieces, each 20' 0"	400.00	
10 pieces, each 8' 6"	85.00	
Total.....	<u>3,080.00</u>	2,566.66

Partition Studding.

	Lineal Ft.	Ft. B. M.
First floor, 2"×4"; $\frac{2}{3}$ ft. B. M., per lineal ft.:		
Studs, 160 pieces, each 9' 9"	1,560.00	
Sills, 16 pieces, each 15' 0"	<u>240.00</u>	
Total.....	1,800.00	1,200.00
Second floor, 2"×4"; $\frac{2}{3}$ ft. B. M., per lineal ft.:		
Studs, 180 pieces, each 9' 9"	1,755.00	
Sills, 10 pieces, each 15' 0"	<u>150.00</u>	
Total.....	1,905.00	1,270.00
Attic, 2"×4"; $\frac{2}{3}$ ft. B. M., per lineal ft.:		
Studs, 54 pieces, each 8' 9"	472.50	
Studs, 133 pieces, each 6' 6"	<u>864.50</u>	
Total.....	1,337.00	891.33

Miscellaneous.

	Lineal Ft.	Ft. B. M.
Lookouts:		
50 pieces, each 3"×1"×2'		25.00
37 pieces, each 6"×1"×2'		37.00
Furring, for brick walls, 1"×2"; $\frac{1}{8}$ ft. B. M., per lineal ft.:		
125 pieces, each 11' 0"	<u>1,375.00</u>	<u>229.16</u>
Grand total of framing.		17,906.25

Cost.

The cost of the framing is estimated with the following analysis as a basis:

Cost of 1,000 Feet B. M. of Hemlock.

(Including framing.)

1,000 ft. of hemlock.....	\$14.00
Nails and spikes, allowing 100 lb. to 3,000 ft. of lumber, at \$1.80 per 100 lb.....	.60
Labor, taking 50 per cent. of the cost of material as cost of framing.....	7.00
Cost per thousand feet B. M.....	\$21.60

Summary.

The amount of material, as previously estimated, is 17,906.25 ft. B. M., which, at \$21.60 per M, will make the total cost of framing.....	\$386.77
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SHEATHING AND SHINGLES.

Quantities.

Sheathing.

	Ft. B. M.
Main roof, 2,200 sq. ft. $\times$ 1 in.....	2,200.00
Tower roof, 370 sq. ft. $\times$ 1 in.....	370.00
Porch roof, 637 sq. ft. $\times$ 1 in.....	637.00
Outside walls, 2,417 sq. ft. $\times$ 1 in.....	2,417.00
Total sheathing.....	5,624.00

Shingles.

Area to be covered (see wall sheathing), 2,417 sq. ft.
= 24.2 squares.

Shingles, 4 in. wide, and 5 in. exposure, num- ber per square.....	720
Number of shingles required, 24.2×720	17,424
Add 5 per cent. for waste.....	871
Total shingles.....	18,295

Cost.

The cost of sheathing in place is assumed to be the same as that for hemlock lumber, \$21.60 per M. The total sheathing is 5,624 square feet, which, at \$21.60 per M, will make the cost of sheathing..... \$121.48

The cost of shingles is based on the following analysis:

Cost of 1,000 Shingles in Place.

1,000 shingles XXX.....	\$5.00
Labor: one man can lay about 1,500 shingles per day; wages being \$2.25, 1,000 will cost.....	1.50
Nails (about).....	.25
Cost per thousand.....	\$6.75

From the preceding estimate, the number of shingles required is 18,295, which, at \$6.75 per 1,000, will make the cost of shingles in place..... \$123.49

Summary.

Sheathing.....	\$121.48
Shingles.....	123.49
Total cost of sheathing and shingles.....	\$244.97

FLOORING.**Quantities.**

	Sq. Ft.
First floor, area (net).....	1,312
Second floor, area (net).....	1,312
Attic floor, area (net).....	1,071
Porch floors, area (net).....	5,523

Hemlock Under Flooring.

Ft. B. M.

Adding 25 per cent. to the net areas to allow for matching and waste, the quantity of $\frac{7}{8}$ -inch rough flooring required for the first two floors is $2,624 + (2,624 \times .25) =$ 3,280

White-Pine Finish Flooring.

Ft. B. M.

The total area of the first, second, and third floors is 3,695 square feet. Adding 25 per cent. for waste, the quantity of $\frac{7}{8}$ -inch flooring is 3,695 sq. ft. + $(3,695 \times .25) = \dots\dots\dots 4,619$

Yellow-Pine Porch Flooring.

Increasing the net area of the porch floor by 25 per cent., the flooring required is 523 sq. ft. + $(523 \times .25) = \dots\dots\dots 654$

Cost.

The estimated cost of flooring may be analyzed as follows:

Cost of 1,000 Feet B. M., Rough Flooring.

1,000 ft. B. M., hemlock.....	\$17.00
Labor, 50 per cent. of cost of lumber.....	8.50
Nails, 33 lb., at \$1.80 per 100 lb.	.60
Cost per thousand feet B. M.....	<u>\$26.10</u>

Cost of 1,000 Feet B. M., Finish Flooring.

1,000 ft. B. M., No. 2 white pine.....	\$22.00
Labor, 50 per cent. of cost of lumber.....	11.00
Nails.....	.60
Cost per thousand feet B. M.....	<u>\$33.60</u>

Cost of 1,000 Feet B. M., Porch Flooring.

1,000 ft. B. M., No. 2 yellow pine.....	\$20.00
Labor.....	10.00
White lead for joints (about).....	.50
Nails.....	.60
Cost per thousand feet B. M.....	<u>\$31.10</u>

Summary.

Hemlock, 3,280 ft. B. M., at \$26.10 per M.....	\$85.61
White pine, 4,619 ft. B. M., at \$33.60 per M.....	155.19
Yellow pine, 654 ft. B. M., at \$31.10 per M.....	20.34
Total cost of flooring.....	<u>\$261.14</u>

MISCELLANEOUS ITEMS.

Quantities.

Yellow-Pine Lumber.

Ft. B. M.

Porch ceiling, same as porch flooring..... 654

No. 1 White-Pine Dressed Lumber

Cornice, 393 ft. $\times$ 2 ft. 6 in. (the combined width of the plain members) $\times$ $1\frac{1}{4}$ in. thick..... 1,228

Spandrels, 357 sq. ft., 1 in. thick..... 357

Base, 128 lin. ft. $\times$ 6 in. $\times$ 1 in..... 64

16 porch posts, 9 ft. $\times$ 8 in. $\times$ 8 in..... 768

Total 2,417

Cost.

The cost of yellow-pine ceiling is the same as that for yellow-pine flooring, less cost of white lead for joints, or \$30.60.

The cost of No. 1 white-pine lumber may be analyzed as follows:

Cost of 1,000 Feet B. M. of Planed Lumber.

No. 1 white pine, \$30.00 per M..... \$30.00

Labor, 50 per cent. of cost of lumber..... 15.00

Nails, 33 lb., at \$1.80 per 100 lb..... .60

Cost per thousand feet B. M..... \$45.60

Summary.

654 ft. B. M., yellow-pine ceiling, at \$30.60 per M.. \$20.01

2,417 ft. B. M., white-pine dressed lumber, at \$45.60

per M..... 110.21

Total cost of miscellaneous items..... \$130.22

RECAPITULATION OF COST OF CARPENTRY.

Framing..... \$386.77

Sheathing and shingles..... 244.97

Flooring..... 261.14

Miscellaneous items..... 130.22

Total cost of carpentry..... \$1,023.10

ROOFING.

FRAMING AND SHEATHING.

68. Roof framing and sheathing are included in the estimate for carpentry.

SLATING.

Quantities.	Squares.
Main and dormer roofs.....	22.0
Porch roof.....	6.4
Tower roof, 370 sq. ft.....	3.7

Cost.

The cost of slating may be estimated as follows:

<i>Cost of 1 Square of Slating.</i>	Per Square.
Slates, 8" × 12" (6" × 12", \$4.00).....	\$5.00
Labor: 1 slater will average 2 squares per day; wages being \$2.00 per day, 1 square will cost.	1.00
Nails: 8" × 12" slates require 5 lb. 9 oz. (5.6 lb.) of galvanized nails per square, which, at \$2.20 per 100 lb., cost.....	.12
(6" × 12" require 7 lb. 6 oz., or 7.4 lb., costing 16 cents.)	
Roofing felt, 1 roll.....	2.40
Labor and nails for laying felt	.15
(Flashing, etc., itemized separately.)	
Cost per square.....	\$8.67

Summary.

Main, dormer, and porch roofs, 28.4 squares, at \$8.67 per square.....	\$246.22
Tower roofs, 3.7 squares of 6" × 12" slates at \$8.21 per square (cost per square for labor, \$1.50, to compensate for extra work in cutting, etc.)....	30.38
Cost of slating.....	\$276.60

MISCELLANEOUS ITEMS.

Quantities and Cost.

Tin roof on bay window, 38 sq. ft., at 11 cents per sq. ft.....	\$4.18
Tin for valleys, 191 sq. ft., at 10 cents per sq. ft...	19.10
Flashing around chimneys and dormers, 90 sq. ft., at 10 cents per sq. ft.....	9.00
Gutters, 100 lin. ft., 26 in. wide, at 21½ cents per ft.	21.50
Conductor pipe, 4-inch galvanized iron, 146 lin. ft., at 20 cents per lin. ft.....	29.20
Terra-cotta ridge tiles, 70 lin. ft., at 40 cents per lin. ft.....	28.00
Terra-cotta finials, 3, 2 ft. high, at \$6.00 each.....	18.00
Tower finial, copper.....	10.00
Total.....	<u>\$138.98</u>
(Labor included in above prices.)	

RECAPITULATION OF COST OF ROOFING.

Slating	\$276.60
Miscellaneous	<u>138.98</u>
Total cost of roofing.....	\$415.58

PLASTERING.

69. Plastering varies in price according to its position and quality. It is therefore necessary to make a separate schedule of each class of work, so that any increase or decrease in quantity may be easily added to or deducted from the estimate.

Quantities.

<i>Three-Coat Work.</i>	Sq. Ft.	Sq. Yd.
First-story walls, 542' × 9' 9⅜".....	5,284.5	
First-story ceiling (take measurement of flooring).....	1,312	
Second-story walls, 609' × 9'.....	5,481	
Second-story ceiling.....	1,312	
Attic walls, 190' × 8' + 156' × 6'.....	2,456	
Attic ceiling.....	<u>831</u>	
Total of three-coat plastering....	16,676.5	<u>1,853</u>

Two-Coat Work.

	Sq. Ft.	Sq. Yd.
Cellar ceiling, use same measurements as for concrete cellar floor		143.6

Cornices.

Cornice, 147' × 2' girth.....	294
Cornice, 493' × 1' girth.....	<u>493</u>
Total sq. ft. of cornice.....	787

Cost.

The cost of the plastering is based on the following analyses:

Cost of 100 Square Yards of Three-Coat Plastering.

1,440 laths, 1½ in. wide, ⅜ in. spacing, at \$2.10 per 1,000	\$3.02
10 lb. 3d. nails, at \$2.05 per 100 lb.....	.20
Labor: putting on lath, carpenter, 1 day.....	2.25
13 bushels of lime, at 25 cents per bushel.....	3.25
1 bushel of hair, 8 lb., at 4 cents per lb.....	.32
1½ loads of plastering sand, at \$1.50 per bushel.....	2.25
⅓ barrel of plaster of Paris, at \$1.50 per barrel.....	.50
Labor:	
Plasterer, 3¼ days, at \$3.00 per day.....	9.75
Helper, 2½ days, at \$1.50 per day.....	3.75
Cartage.....	<u>1.00</u>
Total.....	\$26.29
Cost per sq. yd., \$26.29 ÷ 100 = 26 cents, approximately.	

Cost of 100 Square Yards of Two-Coat Plastering.

Cost of lath, nails, and carpenter work, same as for three-coat work.....	\$5.475
10 bushels of lime, at 25 cents per bushel.....	2.50
¾ bushel, or 6 lb., of hair, at 4 cents per lb.....	.24
1 load of sand	1.50
⅓ barrel plaster of Paris, at \$1.50.....	.50

Labor:

Plasterer, $2\frac{1}{4}$ days, at \$3.00 per day.....	\$6.75
Helper, $2\frac{1}{4}$ days, at \$1.50 per day.....	3.375
Cartage.....	1.00
Total.....	<u>\$21.34</u>

Cost per sq. yd., $\$21.34 \div 100 = 21$ cents, approximately.

Cost of Stucco Cornice per Square Foot.

Assumed cost per square foot..... \$0.24

Summary.

From the preceding estimates of quantities and costs the following figures are obtained:

1,853 sq. yd. of 3-coat work, at 26 cents per sq. yd..	\$481.78
143.6 sq. yd. of 2-coat work, at 21 cents per sq. yd..	30.16
787 sq. ft. of stucco cornice, at 24 cents per sq. ft..	188.88
Total cost of plastering	<u>\$700.82</u>

JOINERY.

70. As there are so many different sizes in the joinery work, no attempt has been made to make detailed estimates of the cost of each; but the general method of obtaining the costs is that given in the preliminary articles on "Joinery."

DOOR FRAMES.*First Floor.*

Chestnut frames—jamb $1\frac{1}{8}$ " rabbeted; casing $\frac{7}{8}$ " $\times$ $5\frac{1}{2}$ ", with $\frac{1}{4}$ -inch edge mold; back-band molding $\frac{7}{8}$ " $\times$ 2"; plinth and corner blocks:

1 frame, 3' 2" $\times$ 7' 9" $\times$ 6" (vestibule).....	\$3.39
1 frame, 3' 2" $\times$ 7' 9" $\times$ 9" (3-inch jamb), front door..	4.14
1 frame, 5' 6" $\times$ 7' 9" $\times$ 14" (sliding door).....	3.86
1 frame, 4' $\times$ 7' 9" $\times$ 14".....	3.75
1 frame, 3' $\times$ 7' 9" $\times$ 14".....	3.62
2 frames, 2' 8" $\times$ 7' 9" $\times$ 6", \$3.33 each.....	6.66
2 frames, 22" $\times$ 7' 9" $\times$ 4", \$2.32 each.....	4.64

White pine—jambs $6'' \times 11\frac{1}{8}''$ rabbeted; casings $\frac{7}{8}'' \times 5''$;
back-band molding $2'' \times \frac{7}{8}''$; plinth and corner
blocks:

4 frames, $2' 8'' \times 7' 9''$, \$3.33 each.....	\$13.32
2 frames, $2' 6'' \times 7' 9''$, \$3.24 each.....	6.48
1 frame, $2' 10'' \times 7' 9''$	3.38
Total.....	\$53.24

Second Floor.

White pine, similar to first floor:

8 frames, $2' 8'' \times 7' 6''$, \$3.28 each.....	\$26.24
6 frames, $2' 6'' \times 7' 6''$, \$2.98 each.....	17.88
1 frame, $2' 2'' \times 7' 6''$	2.72
1 frame, $2' 4'' \times 7' 6''$	2.80
1 frame, $2' 6'' \times 7' 0''$	2.70
Total.....	\$52.34

Attic.

White pine, similar to second-floor doors:

6 frames, $2' 8'' \times 6' 8''$ at \$2.72.....	\$16.32
1 frame, $2' 6'' \times 6' 6''$	2.48
Total.....	\$18.80

Summary.

First floor.....	\$53.24
Second floor.....	52.34
Attic.....	18.80
Total cost of door frames.....	\$124.38

DOORS.

The prices of doors do not include hardware or labor in hanging, both of which items will be found in the hardware bill.

First Story.

Solid chestnut, 6 and 7 raised panels, planted moldings:

1 pair sliding, $2' 9'' \times 7' 9'' \times 2''$	\$16.20
1 single sliding, $4' \times 7' 9'' \times 2''$	14.13

1 single sliding, 3' $\times$ 7' 9" $\times$ 2".....	\$9.26
1 lavatory, 2' 4" $\times$ 6' $\times$ 1 $\frac{3}{4}$ " (frame included in paneling).....	7.46
2 closet doors, 22" $\times$ 7' 9" $\times$ 1 $\frac{3}{4}$ ", solid molded, including glass in upper panel, at \$5.60 each.....	11.20

Veneered Chestnut Doors.

1 front door, 3' 2" $\times$ 7' 9" $\times$ 2 $\frac{1}{4}$ ", 3-panel, glass in top panel, price, including glass.....	\$12.55
1 vestibule door, 3' 2" $\times$ 7' 9" $\times$ 2 $\frac{1}{4}$ ", 3-panel, glass in top panel, price, including glass.....	12.55

Veneered Chestnut and Pine Doors.

1 in butler's pantry, 2' 8" $\times$ 7' 9" $\times$ 2".....	\$8.32
1 in butler's pantry, 2' 8" $\times$ 7' 9" $\times$ 1 $\frac{3}{4}$ ".....	7.95

White-Pine Doors, Raised Panels.

2 glass doors, 2' 4" $\times$ 5' $\times$ 1 $\frac{1}{4}$ ", 1-panel, at \$1.50 (china closet, no frames).....	\$3.00
4 doors, 2' 8" $\times$ 7' 9" $\times$ 1 $\frac{3}{4}$ ", 5-panel, solid moldings, at \$2.50 each.....	10.00
2 doors, 2' 6" $\times$ 7' 9" $\times$ 1 $\frac{3}{4}$ ", 5-panel, solid moldings, at \$2.30 each.....	4.60
1 door, 2' 10" $\times$ 7' 9" $\times$ 2", 5-panel, solid molded....	3.00
2 outside cellar doors, at \$1.00 each.....	2.00
Total.....	\$122.22

Second Floor.

1 $\frac{1}{2}$ -inch white pine, 5-panel, solid molded, raised panels:	
8 doors, 2' 8" $\times$ 7' 6", at \$2.30.....	\$18.40
6 doors, 2' 6" $\times$ 7' 6", at \$2.15.....	12.90
1 door, 2' 6" $\times$ 3' 6".....	1.00
1 door, 2' 2" $\times$ 7' 6".....	2.00
1 door, 2' 4" $\times$ 7' 6".....	2.10
2 wardrobe doors, 2' 2" $\times$ 6' $\times$ 1 $\frac{1}{4}$ ", including glass panels, at \$1.50 each.....	3.00
Total.....	\$39.40

Attic.

White pine, similar to second floor:

1 stuck-molded door, 2' 6" × 6' 6", glass panel.....	\$2.76
6 doors, 2' 8" × 6' 8", at \$2.00.....	12.00
Total.....	\$14.76

Summary.

First story.....	\$122.22
Second story.....	39.40
Attic.....	14.76
Total cost of doors.....	\$176.38

WINDOW FRAMES.

Cellar.

No. 2 white pine, 1½" × 7" rabbeted jambs and head, and 2" × 7" sill. Complete, set in place:

1 window, 3 lights, 13" × 10".....	\$1.09
2 windows, 1 light, 16" × 10", at \$.79 each.....	1.58
4 windows, 2 lights, 14" × 10", at \$.92 each.....	3.68
3 windows, 2 lights, 11" × 10", at \$.82 each.....	2.46
2 windows, 2 lights, 13" × 10", at \$.87 each.....	1.74
1 window, 3 lights, 11" × 10".....	1.03
Total.....	\$11.58

First Story.

Frames in Brickwork.

Box frames, pulley stiles and hanging stiles 1½", sills 2", and outer casing 7⁄8", all of No. 2 white pine. Inside casing with molded back band 5½" × 7⁄8", stool 4" × 1½", apron 5" × 7⁄8", sash stop ½" × 1½". Complete, set in place:

1 window, 2 lights, 40" × 32".....	\$4.13
2 windows, 2 lights, 38" × 32", at \$3.30 each.....	6.60
1 window, 2 lights, 24" × 32".....	3.60
1 window, 2 lights, 34" × 32".....	3.80
2 windows, 2 lights, 36" × 32", curved, at \$7.80.....	15.60
	\$33.73

Forward	\$33.73
1 window, 2 lights, 30" × 32"	3.90
1 window, 2 lights, 22" × 24"	3.36
1 window, 4 lights, 31" × 32" (double)	6.80
2 windows, 3 lights, 15" × 28" (casement), at \$4.00	8.00
Total	<u>\$55.79</u>

Frames in Wooden Walls.

Pulley stiles $1\frac{1}{8}"$, sill 2", subsills $1\frac{1}{8}"$, outside casings $\frac{7}{8}"$, inside casing with molded back band $5\frac{1}{2}" \times \frac{7}{8}"$, stool 4" × $1\frac{1}{8}"$, apron $5" \times \frac{7}{8}"$, sash stop $\frac{1}{2}" \times 1\frac{1}{2}"$, all of white pine. Complete, set in place:

1 window, single light, 14" × 28"	\$3.00
3 windows, 2 lights, 26" × 32", at \$3.44 each	10.32
1 window, 2 lights, 22" × 32"	3.24
Total	<u>\$16.56</u>

Second Story.

1 window, single light, 14" × 28"	\$3.00
2 windows, single light, 44" × 28", at \$4.35 each	8.70
2 windows, single light, 23" × 28", at \$3.30 each	6.60
3 windows, single light, 28" × 28", at \$3.47 each	10.41
2 windows, single light, 36" × 28" (curved), at \$7.36 each	14.72
3 windows, single light, 26" × 28", at \$3.29 each	9.87
1 window, single light, 20" × 28"	3.37
4 windows, single light, 30" × 38", at \$3.67 each	14.68
Total	<u>\$71.35</u>

Attic.

2 windows, single light, 18" × 18", at \$3.06 each	\$6.12
1 window (circular), 24" diameter	3.00
2 double windows, two lights, 22" × 24" (curved), at \$6.48 each	12.96
1 double window, 2 lights, 21" × 24"	3.20
1 double window, 2 lights, 28" × 20"	6.60
1 double window, 2 lights, 24" × 20"	6.30
1 window, 2 lights, 28" × 20"	3.25
1 window, 2 lights, 30" × 28"	3.67
Total	<u>\$45.10</u>

Summary.

Cellar	\$11.58
First story in brick walls	55.79
First story in frame.....	16.56
Second story.....	71.35
Attic.....	45.10
Total cost of window frames.....	\$200.38

WINDOW SASH.

Cellar.

1½-inch white pine, glazed (price does not include hardware):	
1 sash, 3 lights, 13" × 10".....	\$0.64
2 sashes, 1 light, 16" × 10", at \$.27 each.....	.54
4 sashes, 2 lights, 14" × 10", at \$.36 each.....	1.44
3 sashes, 2 lights, 11" × 10", at \$.33 each.....	.99
2 sashes, 2 lights, 13" × 10", at \$.31 each.....	.62
1 sash, 3 lights, 11" × 10".....	.50
Total.....	\$4.73

First Story.

Chestnut, 1¾-inch, prices including glazing, hanging sash, and putting on stops:

1 pair, single light, 40" × 32".....	\$5.66
2 pairs, single light, 18" × 32", at \$2.50 per pair....	5.00
1 pair, single light, 24" × 32".....	2.75
1 pair, single light, 34" × 32".....	3.51
2 pairs, single light, 36" × 32" (curved), at \$9.00 per pair	18.00
2 pairs, single light, 31" × 32" (double), at \$4.02 per pair	8.04
1 pair, single light, 30" × 32".....	4.02
1 pair, single light, 22" × 24".....	2.62
2 pairs, 3 lights, 15" × 28" (casement), at \$4.37.....	8.74

Pine:

1 sash, 1 light, 14" × 28".....	1.25
3 pairs, 2 lights, 26" × 32", at \$3.58 per pair.....	10.74
1 pair, 2 lights, 22" × 32"	2.96
Total.....	\$73.29

Pine:

Second Story.

1 sash, 1 light, 14" × 28"	\$1.25
2 sashes, 2 lights, 44" × 28", at \$5.00 per pair	10.00
2 sashes, 1 light, 23" × 28", at \$2.75 per pair	5.50
3 sashes, 1 light, 28" × 28", at \$3.31 per pair	9.93
2 sashes, 1 light, 36" × 28" (curved), at \$8.42	16.84
3 sashes, 1 light, 26" × 28", at \$3.17 per pair	9.51
1 sash, 1 light, 20" × 28"	2.50
4 sashes, 1 light, 30" × 28", at \$3.54	14.16
Total	<u>\$69.69</u>

Attic.

2 pairs, 2 lights, 18" × 18", at \$1.80	\$3.60
1 pair, circular, 24" diameter	2.60
4 pairs, 2 lights, 22" × 24" (curved), at \$4.22	16.88
2 pairs, 2 lights, 21" × 24", at \$2.10	4.20
3 pairs, 2 lights, 28" × 20", at \$2.50	7.50
2 pairs, 2 lights, 24" × 20", at \$2.12	4.24
1 pair, 2 lights, 30" × 28"	2.50
Total	<u>\$41.52</u>

Screen Frames for Porch.

Rails and stiles, white pine, 4" × 1½", two muntins each:

1 frame, 36" × 16"	\$0.30
1 frame, 90" × 16"	1.00
1 frame, 88" × 16"	.95
1 frame, 60" × 16"	.60
2 frames, 94" × 16", at \$1.10 each	2.20
2 frames, 66" × 16", at \$.65 each	1.30
1 frame, 24" × 16"	.25
1 frame, 84" × 16"	.90
1 frame, 20" × 16"	.20
Total	<u>\$7.70</u>

Summary.

Cellar	\$4.73
First story	73.29
Second story	69.69
Attic	41.52
Screens	7.70
Total cost of window sash	<u>\$196.93</u>

STAIRS.

Cellar Stairs.

52 ft. of hemlock, at \$.014 per ft.....	\$0.73
46 ft. of planed white pine, at \$.03 per ft... ..	1.38
Labor: 12 risers, at \$.20 each.....	2.40
Total.....	<u>\$4.51</u>

Back Stairs.

72 ft. planed white pine, at \$.03 per ft.....	\$2.16
White-pine hand rails, 18 ft., at \$.10 per ft.....	1.80
Labor: 13 risers, at \$.25 each.....	3.25
Total.....	<u>\$7.21</u>

Main Stairs.

335 ft. of hemlock, at \$.014 per ft.....	\$4.69
185 ft. of chestnut, at \$.045 per ft.....	8.33
49 ft. of chestnut hand rail, at \$.50 per ft.....	24.50
86 turned chestnut balusters, 2"×2"×10", at \$.10 each.....	8.60
1 box newel, 8"×8"×4' 6", chestnut, paneled, with molded cap.....	8.00
7 newels, 5"×5"×4' 6", chestnut, with turned pendants, at \$4.00	28.00
2 newels, 5"×5"×12', chestnut, with turned caps, at \$8.00	16.00
Spandrel, 30 sq. ft., 10 raised panels, $\frac{7}{8}$ -inch thick stiles and rails, 1 $\frac{1}{4}$ -inch thick planted molding, at \$.18 per sq. ft.	5.40
Paneled partition under stairs, chestnut, 17 sq. ft., at \$.18 per sq. ft.	3.06
String molding, 46' of 1 $\frac{1}{2}$ "×3", chestnut, at \$.09...	4.14
Skirt molding, 46' of 1 $\frac{1}{2}$ "× $\frac{3}{4}$ ", chestnut, \$.02	.92
Soffit molding, 38' of $\frac{5}{8}$ "×2", chestnut, \$.025	.95
Labor: 35 risers, at \$1.15 each.....	40.25
Total.....	<u>\$152.84</u>

Summary.

Cellar stairs.....	\$4.51
Back stairs.....	7.21
Main stairs.....	152.84
Total cost of stairs.....	<u>\$164.56</u>

MISCELLANEOUS INTERIOR JOINERY.

Baseboard.

First story:

Chestnut, $\frac{7}{8}$ " $\times$ 6", with molding worked on face, tongued into surbase, $1\frac{1}{8}$ " $\times$ 6", 139 ft., at \$.26 per lin. ft.....	\$36.14
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White pine, $\frac{7}{8}$ " $\times$ 9", plain, 90 ft., at \$.055.....	4.95
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Second story:

White pine, $\frac{7}{8}$ " $\times$ 9", molded, 300 ft., at \$.09 per lin. ft.	27.00
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Attic:

White pine, $\frac{7}{8}$ " $\times$ 6", molded, 290 ft., at \$.03.....	8.70
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Total.....	<u>\$76.79</u>
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Wainscoting.

First story:

White pine, $\frac{7}{8}$ " $\times$ $2\frac{1}{2}$ ", beaded and matched boards, 4 ft. high, 132 sq. ft., at \$.065 per sq. ft.....	\$8.58
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Molded cap, $1\frac{1}{2}$ " $\times$ $1\frac{1}{2}$ ", 65 ft., at \$.02 $\frac{1}{4}$ per ft.....	1.46
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Chestnut, paneled, 67' $\times$ 4' high = 268 sq. ft., at \$.18 per sq. ft.....	48.24
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Molded cap, $1\frac{1}{4}$ " $\times$ 4", 67 ft., at \$.10 per ft.....	6.70
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Second story (bathroom):

White pine, $\frac{7}{8}$ " $\times$ $2\frac{1}{2}$ ", matched boards, 4 ft. high, 128 sq. ft., at \$.065 per sq. ft.....	8.32
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Total.....	<u>\$73.30</u>
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Picture Molding.

Chestnut, 3" $\times$ $1\frac{1}{2}$ ", 231 ft., at \$.09.....	\$20.79
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China Closet.

No. 1 white pine, dressed, 97 ft. B. M., at \$.03 per ft.	\$2.91
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Crown molding, $1\frac{1}{2}$ " $\times$ 3", 8 ft., at \$.045 per ft.....	.36
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Labor: 1 man, 2 days, at \$2.25	4.50
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Total.....	<u>\$7.77</u>
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Shelving.

No. 1 white pine, 50 ft. B. M., at \$.03 per ft.....	\$1.50
Labor: 1 man, 1 day, at \$2.25.....	<u>2.25</u>
Total.....	\$3.75

Summary.

Baseboard.....	\$76.79
Wainscoting.....	73.30
Picture molding.....	20.79
China closet.....	7.77
Shelving.....	<u>3.75</u>
Total cost of miscellaneous items.....	\$182.40

MISCELLANEOUS EXTERIOR WORK.*Moldings.*

356 ft. crown molding, $1\frac{1}{8}" \times 4"$, at \$.05.....	\$17.80
356 ft. bed molding, $1" \times 3"$, at \$.03.....	10.68
356 ft. bed molding, $1" \times 1\frac{1}{2}"$, at \$.01 $\frac{1}{2}$	5.34
74 ft. bed molding, $1" \times 2"$, at \$.02.....	1.48
356 ft. bed molding, $\frac{1}{2}" \times \frac{7}{8}"$, at \$.01.....	3.56
64 ft. neck molding, at \$.01.....	.64
36 ft. cove molding, $\frac{7}{8}" \times 1\frac{1}{8}"$, at \$.01 $\frac{1}{4}$	.45

Miscellaneous.

White pine:

35 ft. triglyphs, at \$.10	\$3.50
207 turned balusters, $2" \times 1'6"$, for porches, at \$.10.....	20.70
92 ft. molded hand rail, $5" \times 3"$, at \$.30.....	27.60
92 ft. bottom rail, $5" \times 3"$, at \$.15	13.80
200 dentils, $2" \times 2" \times 3"$, at \$.01.....	2.00
432 ft. B. M., outside window casing, at \$.03.....	12.96
137 ft. window cap, $3" \times 1\frac{1}{2}"$, at \$.02.....	2.74
23 ft. B. M., for balustrade posts, at \$.03.....	.69
Casing for circular window.....	1.00
Semicircular head casing over outside door in dormer.....	<u>1.50</u>
Total cost of exterior work.....	\$126.44

RECAPITULATION OF COST OF JOINERY.

Door frames.....	\$124.38
Doors.....	176.38
Window frames.....	200.38
Window sash.....	196.93
Stairs.....	164.56
Miscellaneous interior joinery.....	182.40
Miscellaneous exterior work.....	126.44
Total cost of joinery.....	\$1,171.47

HARDWARE.

71. The prices given in the following list are based on the use of the best quality of hardware in the market. Should inferior quality be used, these prices would probably be 50 per cent. less. The cost of labor is assumed to be one-fifth the cost of the hardware.

Quantities and Cost.

Locks.

One 5 $\frac{3}{8}$ -inch mortise front-door lock, with bronze furniture complete.....	\$7.50
One 4 $\frac{1}{2}$ -inch mortise vestibule-door lock, with bronze furniture complete.....	7.00
One 5 $\frac{1}{2}$ -inch flush pull mortise lock for double sliding door	3.50
Two 5 $\frac{1}{2}$ -inch flush pull mortise locks for single sliding door, with bronze furniture complete	5.50
Eighteen 4 $\frac{1}{2}$ -inch mortise knob locks, at \$2.20.....	39.60
Ten 4-inch duplex flush cupboard locks, at \$1.85... ..	18.50
Six 2 $\frac{3}{8}$ -inch mortise knob locks, at \$1.60.....	9.60
One 2-inch steel spring padlock.....	.60
Labor, 20 per cent. of cost of locks.....	18.36
Total.....	\$110.16

Hinges

One pair of double-acting checking spring hinges with bronze push plates, for double-acting door	\$10.50
2 pairs 5" × 5" bronze loose pin butts, at \$1.95.....	3.90
33 pairs 4" × 4" bronze loose pin butts, at \$1.40.....	46.20
2 pairs 3" × 3" bronze loose pin butts, at \$.90.....	1.80
Labor, 20 per cent. of cost of butts.....	12.48
Total.....	<u>\$74.88</u>

Miscellaneous.

Thirty-two 1 $\frac{1}{8}$ " × 2 $\frac{5}{8}$ " bronze self-locking sash fasts, at \$.80.....	\$25.60
Five 2" × 2 $\frac{1}{4}$ " bronze cupboard turns, at \$.40.....	2.00
Four 6" × 1 $\frac{1}{4}$ " bronze flush bolts, at \$1.50.....	6.00
Three doz. 5-inch japanned-iron coat hooks, at \$.50.	1.50
1,200 lb. of lead sash weights, at \$.07.....	84.00
1 galvanized-iron hasp and staple.....	.20
1 McCabe patent door hanger, double.....	4.35
2 McCabe patent door hangers, single, at \$3.70....	5.40
6 hanks of solid braided sash cord, 13 $\frac{1}{2}$ lb., at \$.20. per lb	2.70
Four 2 $\frac{1}{4}$ -inch bronze draw pulls, at \$.10	.40
Labor, 20 per cent. of cost	26.43
Total.....	<u>\$158.58</u>

Summary.

Locks	\$110.16
Butts.....	74.88
Miscellaneous.....	158.58
Total cost of hardware	<u>\$343.62</u>

HEATING AND VENTILATING SYSTEM.

72. In taking off quantities for the heating and ventilating contract, attention should be given to the fact that the furnace and pipes, registers and borders, and the fire-place furniture are usually supplied by three different manufacturers.

Quantities and Cost.*Furnace.*

One 53-inch cast-iron portable furnace set up in place \$125.00

Warm-Air and Smoke Pipes.

12 ft. of 4"×8" tin W. A. pipe, at \$0.11.....	\$1.32
12 ft. of 3"×12" tin W. A. pipe, at \$0.12.....	1.44
13 ft. of 4"×10" tin W. A. pipe, at \$0.12.....	1.56
61 ft. of 10" round tin W. A. pipe, at \$0.12.....	7.32
12½ ft. of 8" round tin W. A. pipe, at \$0.10.....	1.25
4 ft. of 8" galvanized-iron smoke pipe, at \$0.15	.60
17 ft. of 10" round fireclay flue lining, at \$0.25....	4.25
2½ ft. of 8" round fireclay flue lining, at \$0.20.....	.50
Labor, one-third of cost of materials.....	6.08
Total.....	<u>\$24.32</u>

Registers.

Three 14"×16" japanned floor registers, at \$2.37..	\$7.11
One 7"×10" japanned floor register.....	.57
One 12"×15" japanned floor register.....	1.50
Two 7"×9" japanned floor registers, at \$0.57.....	1.14
One 10"×12" japanned floor register.....	.84
Two 12"×15" japanned wall registers, at \$1.50....	3.00
One 10"×12" japanned wall register.....	.84
Labor, one-third of cost of materials.....	5.00
Total.....	<u>\$20.00</u>

Tin Register Boxes.

Three 14"×16"×4", at \$0.80.....	\$2.40
One 7"×10"×4", at.....	.57
Two 10"×12"×4", at \$0.75.....	1.50
Two 15"×12"×4", at \$0.75.....	1.50
Two 7"×9"×4", at \$0.57.....	1.14
Labor, one-third of cost of materials.....	2.37
Total.....	<u>\$9.48</u>

Soapstone Borders.

Three for 14"×16" registers, at \$2.22.....	\$6.66
One for 7"×10" register.....	.66
One for 12"×15" register.....	1.47
Two for 7"×9" registers, at \$0.66.....	1.32
One for 10"×12" register.....	1.02
Labor, one-third of cost of materials.....	3.71
Total.....	\$14.84

Miscellaneous.

15 elbows, 10 inches in diameter, at \$0.25.....	\$3.75
2 elbows, 8 inches in diameter, at \$0.20.....	.40
10 sheets of "IC" tin, 20"×28", at \$0.10.....	1.00
2 cold-air boxes, each 24 ft. long, of 20-inch earthen pipe, with two slide dampers and screens, at \$0.80 per foot of pipe.....	38.40
Labor, one-third of cost of materials.....	14.52
Total.....	\$58.07

Summary.

Furnace.....	\$125.00
Warm-air and smoke pipes.....	24.32
Registers.....	20.00
Register boxes.....	9.48
Soapstone borders.....	14.84
Miscellaneous.....	58.07
Total cost of heating and ventilating system.	\$251.71

PLUMBING AND GAS-FITTING.

73. A complete list of the plumbing fixtures, together with the sizes, lengths, and materials of all pipes, should be tabulated so as to be easy of reference in case of alteration in the schedule.

PLUMBING.

Quantities and Cost.

Fixtures.

1 double-oven brick-set kitchen range with water-back; to be selected by the owner; complete...	\$50.00
1 Class A, brown-glazed earthenware sink, 30"×20"×7"; with countersunk slate slab and back 18 inches high, front and side aprons 7 inches deep. Polished brass legs for slab and sink; apron holders, 2-inch cast brass, polished; S trap with waste pipe to floor; and polished improved "Fuller" faucets; complete...	65.00
1 Class A, porcelain recess pantry sink, white enameled inside, with nickel-plated standing waste overflow; with nickel-plated 1½-inch brass trap and pipe to floor; nickel-plated supply pipes to floor; nickel-plated 2-inch supporting stand, and heavy nickel-plated "Fuller" faucets, marked <i>hot</i> and <i>cold</i> ; complete.....	50.00
1 six-foot porcelain-lined, roll rim, Roman pattern, cast-iron bath, with cast-iron feet, painted one coat outside, with nickel-plated combination standing waste, compression star handle supply valves at foot, with <i>hot</i> and <i>cold</i> name plates; complete	68.00
1 improved porcelain siphon-jet water closet, with quartered-oak seat and cover, quartered-oak siphon cistern, with nickel-plated brass brackets, nickel-plated brass flush pipe; nickel-plated chain and china pull, and brass floor flange; complete.....	56.00
1 left-hand corner open lavatory, Italian marble slab, 33"×24", with 16-inch back and end; 5-inch aprons, nickel-plated recess legs; oval basin, 19"×15", ivory tinted; nickel-plated combination supply; "Fuller" faucets; standing waste and trap; nickel-plated pipes to floor; nickel-plated apron holders; china handles to faucets marked <i>hot</i> and <i>cold</i> ; complete.....	58.00
	\$347.00

Forward	\$347.00
1 Italian marble corner lavatory slab 22" × 22", with 12-inch backs; 2 nickel-plated brackets, one 14-inch round basin with hot and cold "Fuller" bibbs; combination standing waste; 1½-inch trap to wall; complete.....	38.00
1 set of 3 Class A, brown-glazed earthenware wash tubs, 30 inches long, 25 inches wide, and 14 inches deep; with 1½-inch lead waste pipe and 2-inch trap; nickel-plated waste plugs and sockets, and nickel-plated "Fuller" pattern flange and thimble faucets for hot and cold; complete...	48.00
Cost of fixtures.....	\$433.00

Water Supply.

1 forty-gallon galvanized-iron boiler, stand, and couplings, complete.....	\$15.00
Tapping and corporation-cock permits.....	5.00
1 curb box.....	2.00
10 ft. of 1-inch brass pipe and fittings	5.00
40 ft. of 1-inch AAA lead pipe	15.00
44 ft. of 1-inch galvanized-iron pipe	4.00
120 ft. of ¾-inch galvanized-iron pipe	7.00
80 ft. of ½-inch galvanized-iron pipe	4.00
30 pounds of fittings.....	5.00
1 one-inch stop and waste cock.....	1.50
8 three-quarter-inch stop and waste cocks.....	7.00
3 half-inch stop and waste cocks.....	2.50
Straps and hangers	1.00
2 garden hose bibbs.....	2.00
Cost of water-supply system.....	\$76.00

Drainage.

213 ft. 4-in. extra heavy cast-iron asphalt-coated soil pipe	\$65.00
20 ft. 3-in. extra heavy cast-iron asphalt-coated soil pipe	4.00
110 ft. 2-in. extra heavy cast-iron asphalt-coated soil pipe	17.00

30 ft. 4-inch extra heavy cast-iron asphalt-coated soil-pipe fittings	\$24.00
4 ft. 3-inch extra heavy cast-iron asphalt-coated soil-pipe fittings	2.50
24 ft. 2-inch extra heavy cast-iron asphalt-coated soil-pipe fittings	7.50
90 ft. of 6-inch salt-glazed earthenware sewer pipe.	10.00
62 ft. of 5-inch salt-glazed earthenware sewer pipe.	6.00
140 ft. of 4-inch salt-glazed earthenware sewer pipe.	8.00
1 six-inch fitting	1.00
7 five-inch fittings	4.00
18 four-inch fittings	7.00
Portland cement	2.00
100 lb. of lead	5.00
Oakum	1.00
Wall hooks	1.00
1 four-inch running trap	2.00
4 four-inch ground brass ferrule cleanouts	2.00
3 cast-iron manhole covers	3.00
1 fresh-air inlet box	1.00
1 four-inch lead bend	1.50
1 four-inch brass ferrule	.20
10 ft. of 2-inch lead waste pipe	2.50
14 ft. of 1½-inch lead pipe	2.50
12 two-inch brass ferrules	1.50
2 two-inch lead traps	2.50
2 square feet of 6-pound sheet lead	.70
3 four-inch wire-basket strainers	.40
20 lb. of wiping solder	4.00
Total	\$188.00

Labor.

Labor, assumed to be one-fourth cost of all materials = $\$697.80 \times .25 =$ \$174.45

Summary.

Fixtures	\$433.00
Water-supply system	76.00
Drainage	188.80
Labor	174.45
Total cost of plumbing	\$872.25

GAS-FITTING.

Quantities and Cost.

Cellar:

Fixtures.

2 brackets, 1 burner, each at \$.50.....	\$1.00
--	--------

First floor:

Parlor, 1 chandelier, 4 burners.....	30.00
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2 brackets, double swing, 1 burner, each at \$5.00.	10.00
---	-------

Dining room, 1 chandelier, 4 burners.....	20.00
---	-------

2 brackets, double swing, 1 burner, each at \$3.00.	6.00
---	------

Hall, 1 chandelier, 4 burners.....	25.00
------------------------------------	-------

Library, 1 chandelier, 3 burners.....	20.00
---------------------------------------	-------

2 brackets, double swing, 1 burner, each at \$3.00.	6.00
---	------

Lavatory, 1 bracket, 1 burner, double swing.....	2 50
--	------

Kitchen, 1 center fixture, 2 burners.....	4 00
---	------

1 side light, single swing, 1 burner.....	1.00
---	------

Butler's pantry, 1 drop light, 2 burners.....	3.00
---	------

Pantry, 1 side light, single swing, 1 burner.....	1.00
---	------

Cellar stairs, 1-bracket light, 1 burner	.50
--	-----

Second floor:

Bedrooms, 11 double swing brackets, 1 burner, at \$4.00.....	44.00
--	-------

Dressing room, 1 double swing, plain, 1 burner....	2.00
--	------

Hall, 1 stiff bracket, 2 burners.....	6.00
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Stair landing, 2 stiff brackets, 1 burner, each at \$3.00.....	6.00
--	------

Bathroom, 1 bracket, double swing, plain, 1 burner.	2.00
---	------

Attic rooms, 5 stiff brackets, 1 burner, each at \$.75..	3.75
--	------

Total.....	\$193.75
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Pipe and Fittings.

54 ft. 1½-inch pipe, at \$0.08.....	\$4.32
-------------------------------------	--------

30 ft. ¾-inch pipe, at \$0.05.....	1.50
------------------------------------	------

30 ft. ½-inch pipe, at \$0.04.....	1.20
------------------------------------	------

205 ft. ⅜-inch pipe, at \$0.03.....	10.25
-------------------------------------	-------

Fittings	4.00
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Total.....	\$21.27
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Labor.

Labor, assumed to be one-seventh the cost of materials (fixtures, pipes, etc.) = $\$215.02 \div 7 = \dots \30.72

Summary of Cost of Gas-Fitting.

Fixtures	\$193.75
Pipe and fittings	21.27
Labor	30.72
Total cost of gas-fitting	<u>\$245.74</u>

RECAPITULATION OF COST OF PLUMBING AND GAS-FITTING.

Plumbing	\$872.25
Gas-fitting	245.74
Total cost of plumbing and gas-fitting	<u>\$1,117.99</u>

PAINTING.

74. In taking off quantities for painting, it is usual to estimate the cost by assuming a price per square yard for each class of work, instead of estimating the material and labor separately.

*Quantities.**Exterior Work.*

Three coats of pure linseed oil and white lead in four colors:

	Sq. Yd.
Shingles (see item in "Carpentry" estimate)	269
Main cornice	130
Porch cornice	22
Porch posts	32
Spandrels	40
Porch skirting	14
Balustrade	52
Sash	64
Window sills	16
Porch floors and steps	72
Total	<u>711</u>

One coat orange shellac and one of varnish:	Sq. Yd.
Porch ceiling (see item in "Carpentry" estimate)	58

Interior Work.

Chestnut finish, parlor, library, dining room, hall, stair hall, lavatory, and stairway. One coat of wood filler, one coat of white shellac, and two coats of varnish, rubbed down with pumice stone and water:

	Sq. Yd.
Architrave	32
Base	16
Wainscoting	30
Sash	17
Doors	54
Jamb casings	7
Stairway	50
Balustrade of stairway	20
Total	226

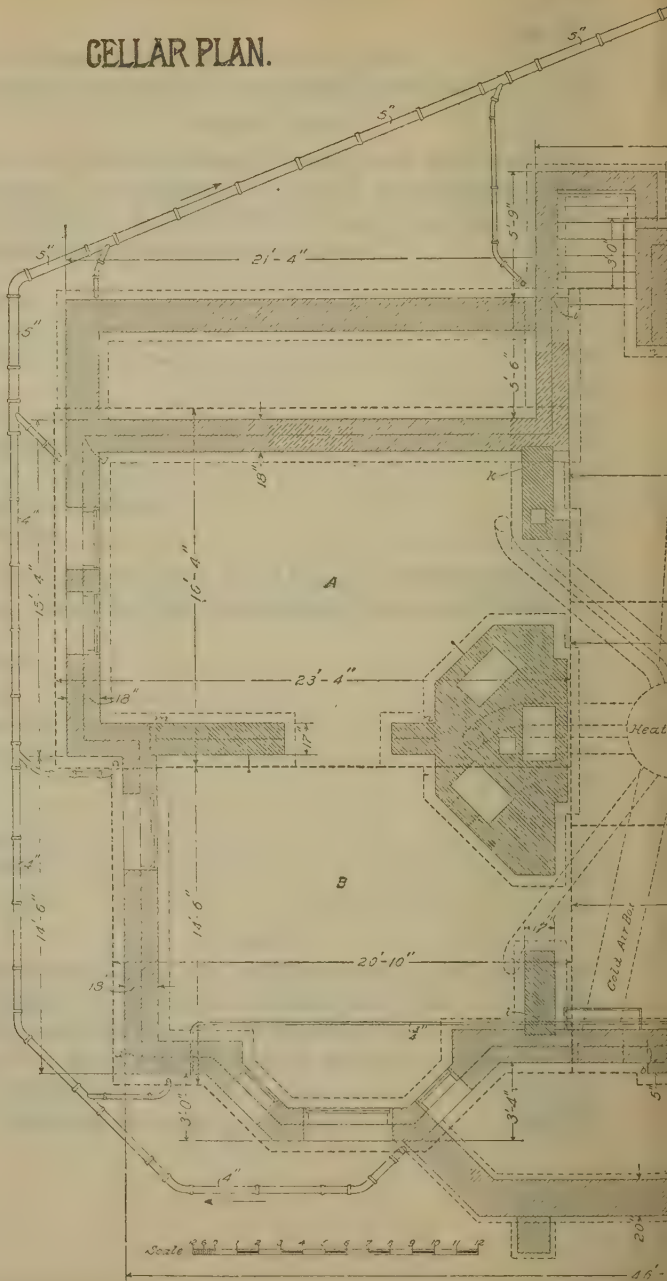
White pine, natural finish, all of house not finished in chestnut. One coat of spirit shellac and two coats of varnish:

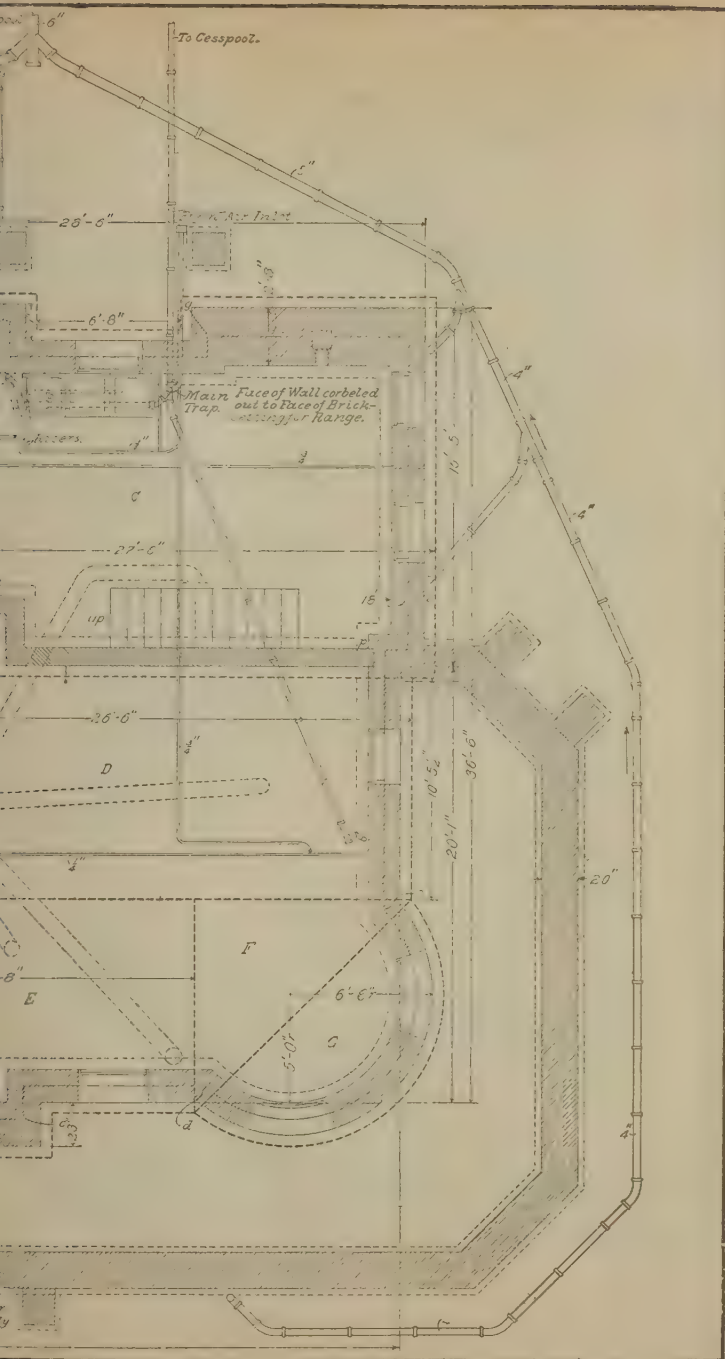
	Sq. Yd.
Architrave	73
Base	60
Wainscoting	29
Sash	40
Dresser	9
Doors	131
Jamb casings	31
Back stairs	34
Total	407

Cost.

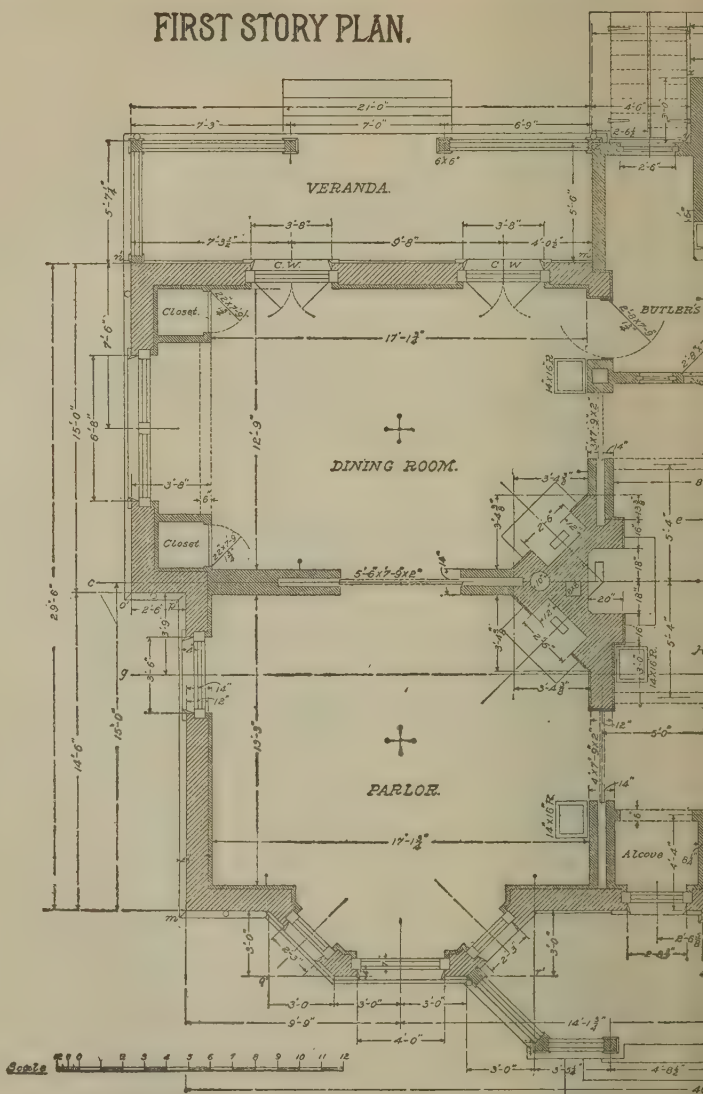
Exterior work, 711 sq. yd., at 28 cents per sq. yd. .	\$199.08
Porch ceiling, 58 sq. yd., at 20 cents per sq. yd. . .	11.60
Chestnut finish, 226 sq. yd., at 50 cents per sq. yd. .	113.00
White pine, natural finish, 407 sq. yd., at 25 cents per sq. yd.	<u>101.75</u>
Total cost of painting	\$425.43

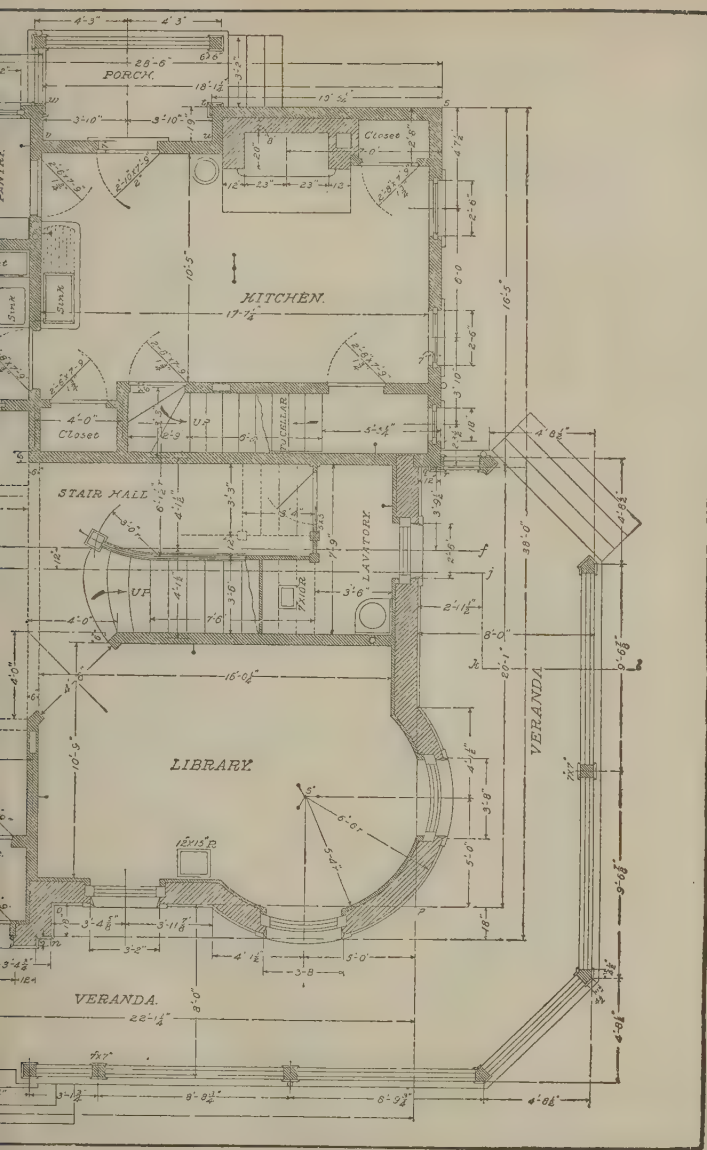
CELLAR PLAN.



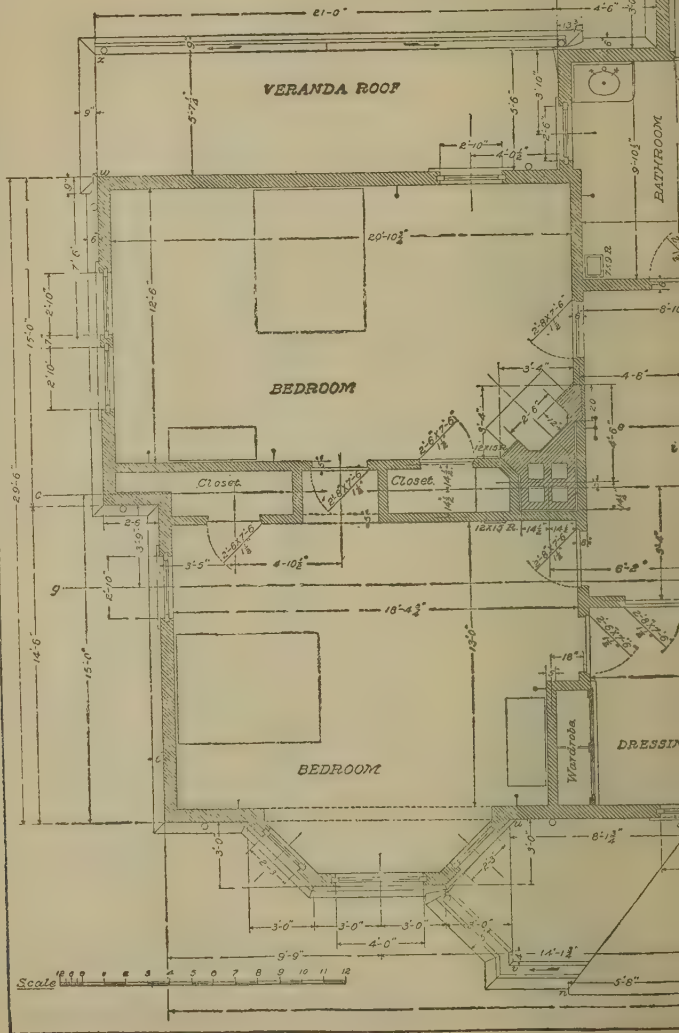


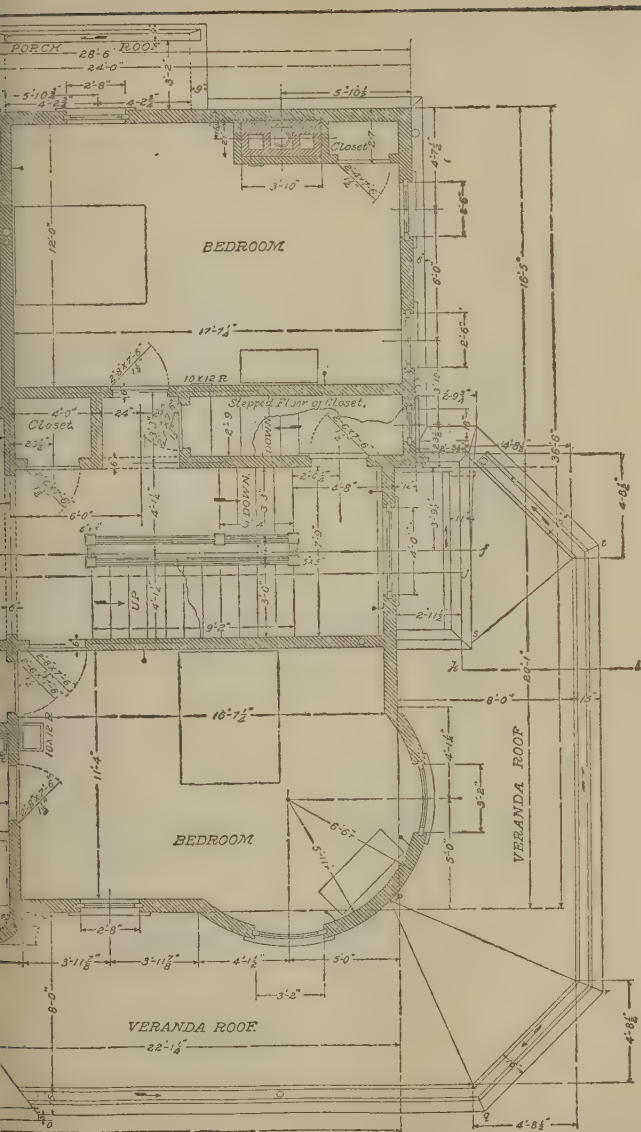
FIRST STORY PLAN.





SECOND STORY PLAN

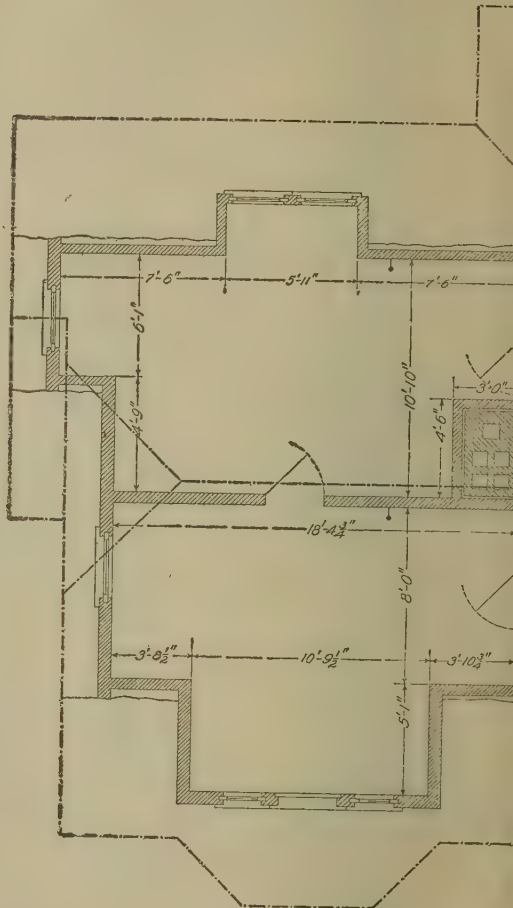


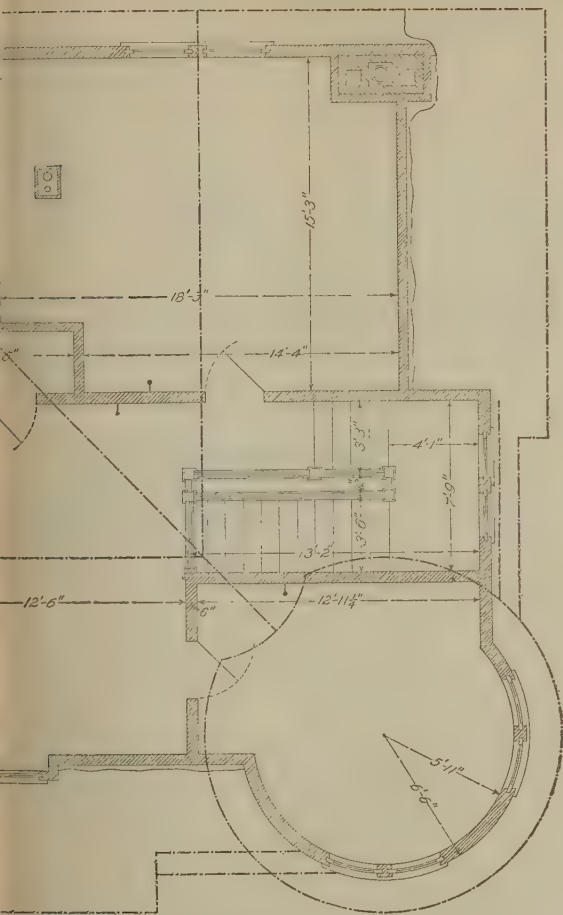


(1872)



ATTIC PLAN.





1 2 3 4 5 6 7 8 9 10 11 12

[illegible]

Longitudinal Section on Line g, h, i,

SUMMARY OF COST OF BUILDING.

75. Having estimated the cost of work required of each trade, a summary of the whole will express the total estimated cost of the building.

Excavation and filling.....	\$174.16
Stonework	1,314.41
Brickwork.....	791.71
Carpentry.....	1,023.10
Roofing.....	415.58
Plastering.....	700.82
Joinery.....	1,171.47
Hardware.....	343.62
Heating and ventilation.....	251.71
Plumbing and gas-fitting.....	1,117.99
Painting.....	425.43
Total cost.....	<u>\$7,730.00</u>

SPECIFICATIONS.

INTRODUCTION.

1. Among the important factors entering into the process of building, the **specification** is justly considered the first. The ability, therefore, to write a definite, particularized, and complete statement of the material, labor, and methods of workmanship demanded in a modern building, is certainly, to architects and builders, a desirable and much-prized acquirement.

The drawings are a reproduction of the architect's design in scale projection, while the specification should be a clear, concise, and, withal, comprehensive statement of the material and methods required to carry the design into execution; when both drawings and specifications are combined, the architect's idea is presented in technical language that may be readily understood by the builder and his artisans.

The writer of a specification should have the design clearly and accurately—fully and in detail—mirrored in his mind, and should, at the same time, possess such definite knowledge of the methods and materials to be employed (varying, of course, according to locality, season, and other circumstances) as to be able to express his conceptions—clear and exact in his own mind—in language at once lucid and concise. Not only should the purpose be well considered, but also the order of treatment of the subject matter of the specification. The instructions as to general principles

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should comprehend the entire work covered by the contract. The arrangement of the specification should, as nearly as possible, follow the order in which the work is to be executed. The description of materials and labor should be clear, definite, and particularized; while the wording should be so precise as to leave no room for doubtful interpretation. Uniformity in the use of words, and the avoidance of more than one term to mean the same thing, tend materially to make the specification clear and explicit at all points.

2. Terms.—Some terms in specifications call for definition or explanation. The word *provide*, used alone, is sufficiently definite, when applied to labor; but, when applied to materials, the phrase *provide and set*, or *provide and erect*, should be employed. *Supply* is a term generally used in connection with materials. *Proper*, or *in a proper manner*, should, when speaking of the execution of work, be taken to mean that the work is to be performed in a manner equal to any other work on the premises; but these terms are to be used as sparingly as possible. *Best* should be accepted in its literal sense; and, in connection with materials, construed to mean that nothing better is to be had; while, referring to labor, it should be taken as meaning the most skilled workmanship available. *Prime cost*, a term generally employed in connection with alterations, deductions, or extras on the work, should be clearly defined to show whether it means the list or catalogue prices, without trade discount; or these prices, without discount for cash; or, again, cost price, with retailer's profit, and charges for cartage and delivery added. *Average* should be avoided as much as possible, for words of such indefinite meaning very often give rise to grave misunderstandings. *Sizes* should be explained to mean either *rough*, *out of*, or *finished*. *Attendance*, or *personal supervision* by the contractor, should be exactly defined, and the amount of labor, as well as the extent of responsibility he assumes, fully understood. *Watching* and *lighting* should be so precisely stated as to make it clear whether watching and lighting are provided for the contractor's own work, or

for that of the subcontractor; or, again, whether there should be a watchman by day as well as by night. But under these terms should also be exactly defined the use of lamps and the character of any especial lighting, to be set up either on the premises, or excavation work in the street, together with special attendance on fires in boilers, etc. *Obtaining permits* is a term that should clearly set forth and should state whether the contractor is to pay the fees charged for permits—whether, for instance, he is to pay for water used for construction purposes on the premises, which is charged for, in some of the larger cities, at the time the permit for tapping the street main is issued.

Under the term *facilities* should be clearly stated the extent of the privileges required; likewise, the purpose of any facilities demanded for reasons other than the inspection of the work. *Provide scaffolding* is specific enough, when scaffolding is intended for the contractor's own purposes. In the case, however, of special scaffolds or platforms, required for other purposes, it is but fair to determine beforehand their location and extent. *Débris* and *rubbish* are generally mentioned in connection with clearing the building of all refuse matter, such as shavings, old mortar, etc., after the artisan has entirely completed his work, or when, at the completion of all other inside work, the joiner commences the interior trimming and finishing. In cases, however, where temporary privies are put in for the accommodation of workmen, the removal of these and all night soil should be specified, separately and distinctly, and not included under *débris* and *rubbish*.

Cast iron, wrought iron, and steel, to be employed in the construction of a building, must be tested for quality and strength. Not only must the tests be specified, but statement should be clearly made as to who shall assume the burden of paying for these tests, whether the material passes the test or not. It should likewise be stated whether the material in question is to be tested at the foundry or rolling mill, or at the building itself, or at both places. In the matter of *drain pipes*, the tests should be defined, and

declaration made as to whether the water, peppermint, mercury, or smoke test be employed for the purpose.

3. Among other points, often overlooked or forgotten, may be mentioned the placing in accessible positions of all traps, pipe connections, cisterns, etc.; the possible necessity of driving sheet piling; the shoring up of embankments and walls of adjacent buildings; the pumping of water from excavations; and the selection of stock, or market sizes and shapes for the several kinds of building material; but, in respect to these and other points not mentioned here, much must be left to the judgment of the writer of the specification, guided, as he must be, as well by the circumstances of the time and place selected for building operations, as by the other concomitants of the case he may have to deal with.

The happiest results in the writing of specifications might, perhaps, be achieved, were the writer to place himself in the position of his client, taking direct personal interest in the judicious expenditure of the moneys at his client's disposal for investment in the building under consideration; also, to take the contractor's point of view and select the most suitable and available materials for construction; and, finally, as clerk of works, to get from the workmen conscientious, intelligent, and accurate labor.

FORM OF SPECIFICATION.

HEADING AND GENERAL-CONDITION CLAUSE.

4. To facilitate the writing of specifications, and to assist the student in this direction, the system adopted and incorporated in the appended copy of a typical specification has been followed. The specification is distinguished from the general matter by being printed in smaller type. All special work or information, not incorporated in the specification for an ordinary building, is printed in *Italics*; and all dimensions enclosed between parentheses are provisional, and subject to

changes demanded by different classes of work or localities. Should the masonry, carpentry, or the work of any other of the principal trades, be made the subject of a separate contract, the specification for each contract should be distinct, preceded by a heading and general-condition clause. The heading is as follows:

SPECIFICATION FOR A FRAME DWELLING.

Specification of the materials and workmanship required, and to be furnished, for the erection of a *frame dwelling* to be constructed for
Mr.

at in the City of

County of and State of

in accordance with drawings and this specification, and under the supervision of

..... Architect Address.

..... Date.

5. The general-condition clause, which should precede the specific description of the work and material required by every specification, is introduced as a precautionary measure, to cover all those details and conditions that are likely to arise in the progress of building erection, and that cannot be foreseen and provided for under the classified headings of the different parts of the specification.

The wording of this clause is very important, as, in the event of a lawsuit over the contract, the provisions of the general-condition clause are likely to become the basis of over half the arguments of the case.

It is usually stipulated in the contract that the general-condition clause, as well as the whole specification, forms a part of the agreement, equally as binding as the contract itself. Those general conditions are affixed to the specifications, so that each and every builder who bids on the work will thoroughly understand his risks and responsibilities, and provide accordingly in his quoted price, so that when he comes to sign the final contract, he will be unable to claim that he did not understand the requirements of the owner, and thus be compelled to make an addition to his price to provide for the stipulation afterwards inserted.

Many of the lawsuits that occur in building transactions are through misunderstandings brought about by omissions from, or an obscure statement in, the general conditions; hence, they should cover all possible contingencies that are likely to arise, and provide for them in such clear and concise language that there can be no possible room for doubt in regard to their meaning. It would also be advisable to leave a few blank lines at the end of the general conditions, so that special stipulations can be inserted should occasion demand it.

Care should be exercised to see that the general conditions are included in the contract, that is, that they may actually be a part of the formal contract; or, as is usually done, form a part of the specifications. When they do thus form a part of the specifications, especially when they are printed on separate sheets and attached thereto, it should be expressly provided that they are to form a part of the specification, and as such are included in the contract. This precaution, though possibly unnecessary, removes all room for subsequent argument.

6. All practising architects who have to deal with their clients' bills, appreciate the necessity of providing in the contract that all transportation shall be prepaid. The material dealers and others furnishing goods that are to be sent from a distance, are often inclined to send them by express, and charge the expressage to the owner; and even where there is no intention of compelling the owner to pay transportation, goods are often sent by freight at the owner's expense, and he is supposed to make a back charge on the shipper's account. This practice causes unnecessary book-keeping for the architect or owner, and should not be tolerated when it is possible to prevent it. It is also advisable to insert a provision in the general conditions to the effect that, before any part of the work can be sublet, the written consent of the owner shall be required. The architect often reserves this right to himself on the ground that, being more familiar with the operation of building, and the standing of

the various contractors, he is more capable to judge of the fit party than the owner. This is not, however, always a wise stand for the architect to take, because it tends to destroy his position as a disinterested adviser, and gives libelous contractors an opportunity to make insinuations of dishonest partiality towards certain mechanics.

The architect would do well to hold his position distinct and separate from the owner, who is one of the contracting parties. In doing so, he will establish himself as an expert judge, rather than the owner's agent, which is always advantageous, and adds dignity and weight to his decisions.

7. The architect should observe the individual workmanship of the men employed by the contractor, so as to guard against the evils arising from the employment of careless or incompetent workmen. Hence, it would seem advisable to insert a stipulation in the general conditions that would give the architect or owner the power to dismiss such workmen.

8. It is well that the contractor should guarantee the work for some stated period, after it is completed and accepted, in order that he may, without additional cost to the owner, make good such defects that may have been overlooked. This will avoid a possible lawsuit where the jury would have to decide the scope of the implied warranty, which exists in all contracts, and how long it held good. Where it is desired to provide this stipulation in the general conditions, it may be stated somewhat as follows: "The contractor is also, at his own cost, to amend and make good any defects, settlements, shrinkage, or other faults in his work, arising from defective or improper materials or workmanship, which may appear within one year after the completion of the building."

9. There is always some expense attached to the carrying out of the rules governing building operations in towns and cities. Outside of the mere expense of securing city permits, etc., there are often the numerous and somewhat changeable wishes of the building inspector to be complied

with. A stipulation, covering the contingency of such expenses, may be inserted in the final contract, though it would be better to place it among the general conditions. The contractor, in bidding on the work, can then take into account the cost that he may incur in complying with such a stipulation.

10. The care of the building during erection should be properly provided for in the general conditions, fixing the responsibility upon the contractor, and stipulating that "he shall provide all necessary guards, rails, and night lights, and be responsible for all property injured upon, or stolen from, the premises."

Where it is desirous to have the building completed by a certain date, it is well to so stipulate in the general conditions, as well as in the contract, for then the builder will not have the excuse that when he bid on the work, he did not know there was to be a time limit. It is much better for the architect, in fixing the time limit, to divide the construction of the building into stages, and to fix successive dates at which each stage shall be completed, instead of stipulating only the date for the completion of the entire job. The advantage of stipulating successive dates for different stages of the work, lies in the fact that the architect is better able, during the progress of the work, to determine whether the builder is likely to finish on time or not. That is, if the builder should fail to have the first or second stages of the work done at the stipulated time, the architect can notify the owner and have the contract rescinded, and it will not be a difficult matter to prove that the builder was negligent. Where, however, only the final date of completion is stipulated, and the architect, judging from the appearances of the work, has reason to believe that the builder will not finish in the stipulated time, may remonstrate with him—the only result being, that he is told by the confident contractor that the work will be completed on the specified time; and should the architect or owner rescind the contract at the early stage of the work, they might be called into court for

damages, and required to prove the incapacity of the builder to finish on time—a thing which might be difficult to do.

11. The general-condition clause should read somewhat as follows:

GENERAL CONDITIONS.

The contractor shall give his personal superintendence to the work, and furnish all materials, transportation, labor, scaffolding, and appliances required for the full performance of the work herein specified, except as may be otherwise definitely mentioned. He shall lay out his work, and be responsible for its correctness; and shall not sublet any part of this work without the written consent of the owner or architect. He shall keep, during working hours, a competent foreman at the works. He shall obtain all the necessary permits, paying the lawful fees charged therefor; shall give the requisite notices to the proper authorities relative to the work in his charge; shall be liable for all accidents to persons, or damage to property, traceable to the negligence of himself or his subordinates, and shall be responsible for any violations of local laws or ordinances. He shall, in fine, duly and adequately protect his work at all time during its progress.

All materials employed in construction are, unless otherwise specified, to be the best of their several kinds, subject to the approval of the architect and owner. All labor is to be performed in the best and most acceptable manner by skilled workmen, and both workmen and workmanship are subject to the architect's approval. All work and materials must conform to the laws and regulations in force in the locality, notwithstanding anything hereinafter specified and provided that may be construed to the contrary. The drawings referred to in this specification are made to a scale of $\frac{1}{4}$ in. = 1 ft., and will be supplemented by detail drawings, furnished as the work progresses.

All these drawings are intended to cooperate with this specification, to form part thereof, and also form part of the contract. Where figures are given, they are to be followed in preference to measurement by scale. The drawings and specifications furnished for this work are instruments of service and the property of the architect, to be returned to him on completion of the work herein set forth.

The contractor shall, while the work progresses, keep the premises in a cleanly condition, free from rubbish and from all undue accumulations of surplus material. He shall, upon the completion of the work, remove all débris and rubbish, repair any damage done to the work, no matter how or by whom caused (except loss or damage by fire), leaving the premises broom clean and in perfect order and repair at the termination of his work. He shall provide all necessary guards, rails, and night lights, and be responsible for all property injured upon, or materials stolen from, the premises.

The work shall be under the supervision of the architect or the architect's representative, who shall, at all times, have access to, and power of inspection over, the works, to accept materials or workmanship in his judgment satisfactory, or reject work and material not in accordance with the drawings and specifications. His decisions as to the interpretation or intent of the drawings and specifications shall be final and binding on all parties concerned.

The owner reserves the right to accept or reject any or all proposals submitted. He shall have the site surveyed and staked, furnishing the necessary lines and levels.

The contractor shall lay out the building in accordance with the drawings and directions, and shall be not only responsible for its due and accurate location on the lot, but liable, besides, for any damages inflicted on the owner or on adjacent property owners, from failure to comply, in this respect, with the drawings and directions.

12. After the general conditions are disposed of, the specification should be divided up under separate headings according to the number of different trades which are represented in the work to be done.

These headings should be prominent and conspicuous, and, when convenient, should be at the head of a page in order that the specification may be divided, if desirable, to give each contractor or subcontractor the portion that relates to his own particular work.

Under each heading there should be subheadings indicative of the different subdivisions of the work, but each general heading should cover all the operations included in the trade which it sets forth. For instance, these headings being "Masonry," "Carpentry," "Plumbing," "Painting," etc., then, under the general heading "Masonry," should be the subheadings of "Excavation," "Mortar," "Pavements," "Walls," etc.

MASONRY.

EXCAVATIONS.

Clear away all rock, dirt, or rubbish; excavate for the cellar, footings, areas, front wall and steps, cesspools, drains, etc.; complete, also, all other excavations required to carry out the work as specified. Excavate to the full depth, as indicated, making the excavation for the

cellar (12 inches) wider all around than shown on the cellar plan. The foundation walls must extend at least (4 feet) below the finished grade of the lot, so as to be under the frost line.

All earth or rock from the excavation, not required for filling in, or grading, is to be removed from the premises. The grade lines, shown on the drawings, are the lines to which the lot is to be graded, after the completion of the building. The existing grades are not shown on the drawings. Fill in the earth around the cellar walls, piers, and cess-pools, along the street wall in front and over the broken stone and gravel filling of the drains, etc. The filling shall, in the case of walls, be done after the mortar is dry, and, in the case of trenches for drains, as soon as the pipe lines are laid and approved by the superintendent. The filling around the walls is, at every foot in height, to be well rammed, the soil banked over the drains, to allow for settling, and the earth sloped away on all sides from the walls of the building.

MORTAR AND CONCRETE.

Lime, cement, sand, and mortar, for all mason work throughout, shall be, unless otherwise specifically stated, as follows: (1) No. 1 *Rockland* lime, freshly burned and well slaked. (2) *Brooklyn Bridge brand Rosendale hydraulic* cement. (3) *Saylor's best English Portland* cement. (4) *Vicat Portland* cement. (5) Sand to be clean, sharp, well screened, and free from loam or salt. (6) The mortar to be thoroughly mixed and made in the following proportions: (a) *Lime mortar*: one part lime, *three* parts sand. (b) *Rosendale cement mortar*: one part cement, *two* parts sand. (c) *Portland cement mortar*: one part cement, *three* parts sand.

Concrete shall be composed of one part *Rosendale* cement, *two* parts sand, and *three* parts clean *broken stone*.

FLOORS, PAVEMENTS, AND COAL CHUTES.

Cellar Bottom.—Level off the earth in the cellar bottom to a depth *six* inches below the finished floor level, tamp it down well at all points, and lay a *Rosendale* cement concrete bottom *five* inches thick; settle it down thoroughly and finish with a (1-inch) top dressing composed of *Portland* cement and sand in equal parts, to be floated to a smooth surface and so graded to the *outside cellar door* that the cellar may be drained. Form in the cellar bottom a channel along the foundation wall, through which to run the house drain, forming along the edge of this channel a lip (1 inch) high, to throw the water off in case the cellar is washed out. This channel is to be graded to meet the grade of the house drain, and shall then be finished with *Portland* cement.

The area bottoms shall be of concrete, the bottom layer of *Rosendale* cement concrete, *three* inches thick, well rammed and leveled up. Finish with (1 inch) of *Portland* cement, hereinbefore described; trowel down to a smooth surface graded to the cast-iron strainer, which shall be furnished and set by the plumber. Other concrete work is specifically stated under the titles "Cesspool," "Trap Pit," etc.

Coal Slide.—Build in a (12-inch) vitrified tile pipe, laid in *Rosendale* cement mortar, firmly bedding it in the wall. This pipe must be given a pitch of not less than (30°); it must be brought up to grade and finished with a (3-inch) *bluestone* flag. Cut an opening in the stone, in which set a cast-iron frame and manhole cover, the frame to be set in cement and well secured to the stone. The cover is to be provided with a suitable wrought-iron chain extending to the inside of the cellar wall, the last link of the chain fitting over a staple firmly attached to the wall.

DRAINS AND CESSPOOLS.

Subsoil Drains.—Lay a *three-inch* porous agricultural tile drain along the footings all around the foundation walls of the building; the crown of the grade shall be at the point (*A*) indicated on the drainage plan; the bottom of the tile drain at this point to be level with the top of the footing stones. Lay the pipe with an even grade to the point (*B*); increase the pipe at this junction to *four* inches, and continue the line with the same grade to the *dry cesspool* in the rear of the premises. The drain must not, at any point around the building, be lower than the lower edge of the footing course. Cover the drain around the building with a good layer of new straw; fill up the trench to within a *foot* of the grade with broken stone, and finish to grade with top soil. Lay *six* lines (in all 400 feet) of *three-inch* agricultural tile, starting at a depth of *one* foot below the surface, and laying at a suitable uniform grade to the main outlet. The main line shall start with a *four-inch* pipe, to be increased at the point indicated to a *six-inch* pipe. From this point, continue the line *six* inches in diameter to the *dry cesspool*. The joints for all agricultural pipe should be open ($\frac{1}{8}$ inch), and, where straw is not used, covered with strips of paper to keep out the earth. Bed the pipe firmly, tamping the ground well on each side, to keep the drain in alinement.

Leader Drains.—Lay the drains of vitrified earthen pipe for the discharge of rain water as follows: From the *two* leaders at the rear, lay lines of *four-inch* pipe as shown, increasing them to *five-inch* pipe, where the front leaders enter; continue the lines to the junction indicated, and from there to the front of the property line lay a *six-inch* pipe. The drain from the front of the property line to the street gutter shall be of *six-inch extra heavy cast-iron* pipe; the drain to

finish at the curb, with a *galvanized cast-iron strainer*, well secured to the face of the curbstone.

All branches and connections on this line of drains shall be made with Y branches, and ($\frac{1}{8}$) bends. The base of each leader, to a height of (3 feet) above the grade, shall be of *extra heavy cast-iron* pipe; the drain pipes are to be firmly bedded in place, and laid with a uniform grade of at least ($\frac{1}{4}$ inch) per foot throughout. All joints shall be made tight and clean, cemented together with hydraulic *Portland* cement mortar, mixed in the proportion of one part cement to *two* parts sand. As each joint is made, any mortar entering the pipe must be thoroughly cleaned out with the hand, or by means of a semicircular hoe-shaped scraper, fitting the inside diameter of the pipe.

Cesspool.—Lay footings and build the walls of the cesspool of good sound quarry stone, the walls to be (20 inches) thick, laid in *Rosendale* cement mortar, carried up and leveled at a point *six* feet above the top of the footings. Lay a *Rosendale* cement concrete bottom (3 inches) thick, tamping it down well, and finishing with a (1-inch) top dressing of *Portland* cement and sand, similar to the cellar-bottom finish. Plaster the walls of the cesspool inside and outside with *Portland* cement mortar. Provide an opening in masonry for overflow, (3 inches) below the inlet; lay a *five-inch* vitrified earthen-pipe line with a uniform grade of ($\frac{1}{4}$ inch) per foot to the blind cesspool, the inlet opening to have an elbow turned down into the cesspool. This overflow pipe is to be laid in a manner similar to drains for leader pipes. The brick dome and finish of the cesspool are specified under the head of brickwork.

Dry Cesspools.—Construct a dry cesspool, of the dimensions shown on plans, *six* feet deep in the clear, the walls to be of sound stone (18 inches) thick, laid up dry. Fill in with small broken stone to the top, and pile the stone in the form of a pyramid, till the top is within *one* foot of the finished grade. Excavate a pit 2 feet square and 2 feet deep under the cellar-entrance area and fill with broken stone.

WALLS.

13. It will be seen that the subheadings do not always follow in the order in which the work is conducted in the building. This change of arrangement is necessary in order that the contractor may be aided as far as possible in making his estimates; therefore, immediately after the description of the kinds and qualities of mortars and cements required, the description of the work follows, which consists largely of concrete or cement.

The same will be observed under the following subheadings, commencing with "Walls." All the work pertaining to the walls is first described, whether the material is brick or stone; then follow the conditions to be observed in the material and workmanship required of the stone mason and the bricklayer.

Footings.—Put down under all walls, chimneys, piers, exterior steps, etc., where solid rock does not occur, footings of large, flat, sound stones, *eight* inches thick, each stone being of the full width indicated, the footing stones under the piers to be in one piece. Flush up to a level bed all around with spalls and *Rosendale* cement mortar.

Foundation Walls.—Build up foundation walls of large, sound quarry stone, well tied and bonded with through stones. The walls up to grade are to be substantial rubble, constructed with good, sound, flat, quarried stone, the through stones to be inserted at intervals of *four* feet in length and *two* feet in height, all walls to be laid to a line on both sides, the joints and interstices in the walls to be well filled with spalls and cement mortar, and all joints weather-pointed inside and out with *Portland* cement mortar. Form pipe chases and all openings in the walls as required by the cellar plan.

Damp Course.—On a line averaging six inches above grade, lay a damp course as follows: Level the wall as much as the stone courses permit, and cover with a good coat of liquid *Trinidad* asphalt, applied hot, covering it with heavy-weight *tarred* paper and finishing with another coat of asphalt on top. Plaster the walls below grade, from footings to damp course, with *Portland* cement mortar and coat with asphalt.

Areas.—Build up the walls of area and cellar steps, and areas for cellar windows, as indicated, with stone (16 inches) thick; cope with *rubbed bluestone* (5 inches) thick, projecting ($\frac{3}{4}$ inch) over the face of the wall; the steps to cellar area to be of *rubbed bluestone* (7 inches) thick, in one piece, with the ends and backs housed into the wall *two* inches. Build foundations for veranda piers, porch piers, and piers for the porte cochère up to grade with sound quarry stone, laid in *Rosendale* cement mortar.

FRONT OR STREET WALL.

Lay the footings (4 feet) below grade, and build the foundation of the wall along the front of property (24 inches) thick, of large, sound quarry stone with flat beds. Level up the footing course with spalls, and build the wall up to grade, laying it in *Rosendale cement* mortar.

Back up the ashlar facing above the street grade to the coping line, with rubblework laid in *Rosendale cement* mortar, taking care to allow none of this mortar to come in contact with the ashlar. Point the foundation, below the grade on both sides, and the backing with *Portland cement* mortar.

Ashlar Facing.—Face the foundation wall above grade with *blue limestone random* ashlar, (6 inches) and (10 inches) in thickness, no piece of ashlar to measure less than (4 in. $\times$ 6 in.) on the face, and no joints to be greater than ($\frac{3}{16}$ inch) in width. Make all joints level, true to a line and broken, no vertical joint to be more than (12 inches) in height. The sides or builds of ashlar must be neatly jointed, and the stones set, without exception, on their natural bed.

Plaster all ashlar on the back, and bed it in mortar composed of *Vicat cement one* part, and sand *two* parts. Rake out all joints to a depth of ($\frac{3}{8}$ inch); clean the face of the stonework with a stiff steel brush, and point the joints with *Vicat cement* mortar. Use a steel jointing tool for the final pointing of this work.

Bond every stone with the *brick* backing, and tie all stones over (8 inches) in height with *galvanized wrought-iron* anchors let *two* inches into the stone and extending at least (4 inches) into the backing. All cut stonework to be executed in strict accordance with the drawings, and as required by the specifications—comprising jamb stones, quoins, lintels, sills, and other dimensioned material, all to be *clean cut* and worked to the form indicated on the detail drawing. Build the piers under the veranda, porch, and porte cochère of *coursed limestone* in rock-faced ashlar, of the dimensions shown on the drawings, and lay with a level bed in *Vicat cement* mortar. Cut a 1-inch *chisel draft* on the corners of the porte-cochère and porch piers, besides *clean-cutting* the cheeks of all piers for the fitting of lattice frames or other woodwork.

Cut a (1-inch) margin all around the top of the porte-cochère piers, but cut the margin on the outside faces only of the veranda and porch piers. Cut, also, a (1-inch) margin all around the top of the foundation wall, and finish the top of the wall to a true level.

Facing.—Face the front or street wall with *rock-faced limestone coursed* ashlar as shown, the wall to be (18 inches) thick above grade, the height and other dimensions to be taken from the drawings. Lay a good coat of *Vicat cement* on top of the foundation wall, and with this cement, plaster the back of all ashlar facing. The method of laying, the thickness of facing, and the width of joints are to be the same as those specified for the foundation walls of the building.

Wall Coping.—Cope the walls with a 5-inch *fine-axed bluestone*, projecting ($\frac{3}{4}$ inch) over the wall on both sides, and pitched on top.

The cover pieces of the coping shall be (7 inches) thick, with lugs cut on, to form a cover joint as shown.

Gate Pillars and Wheel Guards.—Build up the gate and end piers with dimension blocks of stone as indicated; drill all holes for gate hinges, etc. at the points directed. Build in wheel curbs at the carriage entrance as shown, each to be in one piece, *clean-cut* finished.

The **caps of stone pillars** shall be cut in one piece with ball on top and *fine-axed*. All this work shall be well anchored and bonded together, the joints raked out at completion and pointed with strong *Vicat* cement, a steel jointer being used to finish the pointing.

The steps are to be (7 inches) thick, of *rubbed bluestone* in one piece, having (2 inches) cover at ends and back; the cheek pieces are to be (7 inches) thick and (14 inches) long; the topmost step (16 inches) wide. Cope with (5 inches) *fine-axed bluestone*, and finish as indicated.

Cut-Stone Work.—All cut stone used on the premises must be sound, uniform in color, free from seams, sand holes, and other imperfections; all rock-faced work to be newly cut, showing a clean face, free from tool marks. All beds are to be squarely cut, all side cuts vertical through the full depth of the stone, and all corners and edges cut clean and sharp.

Samples of the stone in *six-inch* cubes, having the sides worked to show the cutting and finishing specified, must be submitted to the architect for approval. These samples should be taken from different parts of the quarry, to represent a fair average of the stone in respect to quality and to color. The samples having been approved, the stonework furnished must be, in every respect, equal to these samples.

Bluestone.—All *bluestone* in copings, steps, etc. is to be of clear, sound stock, uniform in color where exposed to view, and free from flaw or imperfection. Set the *bluestone* as here described on its natural bed, in *Portland* cement mortar, except where it may come in contact with ashlar facing or other *limestone* in the foundation walls, when *Vicat* cement shall be used.

Provide and set *fine-axed* templets under the girder ends in the wall (12 in. $\times$ 12 in. $\times$ 5 in.). All piers in the cellar shall have (5-inch) *fine-axed bluestone* caps and *one fine-axed* bond in each, the same size as the piers. Chimney caps, also, are to be *fine-axed*, in one piece (5 inches) thick, and have a projection of *one* inch over the top course of brick. Make the cover over the cold-air duct (3 inches) thick, in lengths at least (30 inches), with a (6-inch) bearing on the wall at each side of the duct. Make the trap-pit cover (3 inches) thick, and (10 inches) larger each way than the size given for the trap pit itself.

Give the lintel over the kitchen fireplace an *eight-inch* bearing on

the jambs, and make it (8 inches) thick, its face and soffit to be *rubbed*. The covers over the cesspools are specified under the head of "Brickwork." Place a step flag *four* inches thick at the foot of veranda and porch steps; set in sand well rammed, bedding the flags evenly, leaving no hollow spaces under them, and giving them a pitch of ($\frac{3}{8}$ inch) to the foot.

Secure and bind together all coping and horizontal stone courses with *brass joggles*, countersunk and set in molten lead.

14. The preceding paragraphs describe the walls and facing of the building, but do not distinctly set forth the special conditions to be observed by the bricklayer. Therefore, under a subheading should be introduced a description of all the brickwork not included in the previous paragraphs under the subheading of "Walls."

BRICKWORK.

All brick shall be *wet* when laid in dry, warm weather, and *dry* when laid in *damp* or *wet* weather. Use sound, hard, well burned brick throughout; the work to be well bonded, tied in every *sixth* course, and worked in *regular* bond with full-flushed joints, leaving no interstices. All walls, piers, etc. are to be plumb and built to an exact line, the walls to have all necessary openings, pipe chases, etc., as required by the drawings. Back up the ashlar facing from the top of the rubble stonework to the sills with brick, backing up each course of stone as it is set. Begin the brickwork on the stone foundation with a rowlock course, and carry the brick up between the floor joists to within (1 inch) of the under side of the flooring. Build window and door jambs plumb and true, and set stone templets under the girder ends in the wall, leaving ($\frac{1}{2}$ inch) space at each side of the girder.

Care must be taken to allow no other than *Vicat cement* mortar to come in contact with the ashlar facing.

Build the partition walls of the cellar to the dimensions stated, and turn *three-course rowlock* arches over the openings in these walls; carry the brick to within (1 inch) of the flooring. Build up the walls of the dumb-waiter shaft in the cellar, of brick, (8 inches) thick, bonding it in every *sixth* course. Build the opening in this shaft, turning a *flat* arch over it, the opening to be (2 ft. $\times$ 4 ft.), with the sill (18 inches) above the finished cellar bottom.

Construct the piers in the cellar to the dimensions given; these piers shall have a (5-inch) bond stone built in half way up, and be capped with a (5-inch) stone.

Furnace Pits, Etc.—Construct the cold-air duct, furnace pit, and trap pit with (8-inch) brick walls, thus forming the sides; the size of the furnace pit is to be obtained from the heating contractor.

The **cold-air duct** is to be (15 in. $\times$ 30 in.), inside measurement, and run from the wall of the building to the furnace pit; the top is to be covered with (3-inch) flagstones laid with close-fitting joints (1 inch) below the cellar bottom, and these flagstones covered over and finished flush with the cellar bottom in *Portland* cement top dressing. Cover the trap pit with a (3-inch) *bluestone* flag, laid flush with the floor. Lay the bottoms with cement concrete, the same as the cellar bottom.

Brick-Set Furnace.—The furnace shall be enclosed with brick walls of the dimensions indicated, the walls to be (10 inches) thick, laid up in *lime*, *Rosendale* cement mortar. These walls shall be built hollow, with a (2-inch) space between, and tied together with *galvanized-iron* anchors, set (24 inches) apart, in every *sixth* course. Set all iron door frames and doors which the heating contractor shall furnish. Form the flues and all openings required. Furnish and set (2 in. $\times$ 1½ in. $\times$ ¼ in.) **T** iron, spaced (8½ inches) on centers. Lay on these bars *two* courses of brick, laying the courses flat and the upper course parallel with the **T** bars. Cover all over with a (2-inch) coat of *Rosendale* cement mortar. While the walls are being laid, plaster the brickwork on the inside with a good coat of mortar, composed of *lime*, *sand*, and *plaster of Paris*, in equal proportions.

Cesspool Dome.—Start the brick dome of the cesspool so that the first course shall measure (18 inches) in width on top of the stone wall, with the next *five* courses raked and laid so that the *seventh* course will bring the brickwork to (8 inches) in thickness. The first course on the inside shall be laid in rowlock, and the dome carried up perfectly round, keeping the inside smooth. Draw in to a manhole (24 inches) in diameter, which shall have a brick ring (8 inches) wide built up *two* courses above the dome. Cover the manhole with a (4-inch) *bluestone* flag, to have at least (8 inches) bearing all around.

Chimneys.—Construct chimneys as required by the drawings, carrying these up perfectly true and plumb, so that in no case shall there be less than (8 inches) of brickwork between the smoke flues and any timber or woodwork. The chimneys must be built entirely free and independent of the framing. Form ash-pits as required by drawings, providing and setting for each a cast-iron frame (12 in. $\times$ 14 in.) with lugs to build into the brickwork, and a cast-iron door properly hung and fastened. All flues shall be run direct and to the top of the chimney, independently of one another. They shall have between them four-inch partitions, and shall, unless otherwise specified, be lined with (8 inches) square fireclay lining, which shall run the entire altitude to the chimney cap, and there be cemented tight. The flue

lining shall be well bedded in the brickwork and built in, while the chimneys are in course of construction.

Run the furnace flue down to within *two* feet of the cellar floor. Provide and set here a cast-iron door (12 in. $\times$ 14 in.), with a cast-iron frame identical with that used for the ash-pit. All other flues not terminating in a fireplace shall be carried down to the cellar and provided with (8 in. $\times$ 10 in.) cast-iron clean-out doors in suitable cast-iron frames. The furnace flue shall be lined with (8 in. $\times$ 12 in.) fireclay pipe, and the ash flues with (4 in. $\times$ 8 in.) fireclay pipe.

Top out the chimneys above the roof, to conform to the detail drawings, carrying the rough brickwork up to the flashing line. The *tinner* shall furnish, and the mason set, painted apron flashings for all chimneys; and these shall be so set in the joints that not less than (6 inches) shall be at any point visible. The flashings shall be stepped on the raking lines of the roof, and the joints on the chimneys well cemented with slater's cement.

The chimneys, from the flashing line to the cap, shall be faced with *red hydraulic pressed brick*, laid up in *lime* and *Rosendale cement* mortar, and pointed with *red* mortar as before specified. Set and bed evenly the chimney caps in *Portland cement* mortar.

Furnish and set in place for the tall chimneys a wrought-iron rod, (1 inch) in diameter, to run through the chimneys. At the rear face of the chimney the rod shall have a shoulder welded on, against which a washer shall be put, before the rod is placed in position. Thread the outside end of the rod for a nut. Flatten the rod out to a flange (2 inches) wide and (10 inches) long, bent to conform to the angle of the roof, and having three spike holes. Spike the rod securely to the roof, flashing around it before the shingles are laid with (6-pound) sheet lead. Wash down all chimneys and the kitchen fireplace as well, when completed, with dilute acid; apply, also, a good coat of raw linseed oil, taking care that no oil or acid comes in contact with or damages the stonework or any other work.

Fireplaces.—Form the rough fireplaces as shown, with *flat* arches on *wrought-iron bars* ($\frac{1}{2}$ in. $\times$ 2 in.), turned up at the ends. Construct proper ledges in the throats of the fireplaces, and insert adjustable iron dampers. Face the fireplace in the *reception hall* with *red hydraulic pressed brick*, standard size, and the fireplace in the *dining room* and *library* with *buff mottled hydraulic pressed brick* ($1\frac{1}{2}$ in. $\times$ 12 in.). The face brick in the fireplaces shall be laid with ($\frac{1}{8}$ -inch) joints, in *lime* and *Rosendale cement* mortar, colored with mineral mortar stains to *match* the brick. The reveals of the fireplace openings shall show (4 inches) of brick.

Build the kitchen fireplace as indicated on the drawings, and face the breast, jambs, and throat with *red hydraulic pressed brick*, laid up with ($\frac{3}{8}$ -inch) joints in *lime* and *Rosendale cement* mortar, colored

to match. Set a *bluestone* lintel, as already described. Keep the face brick of the fireplace full (2 inches) beyond the body of the chimney, so that, when put on, the furring and plastering shall line up with the finished brickwork.

Detail drawings will be furnished for all fireplaces. The color of tile in the facings and hearths shall be selected and determined by the owner. All tile in the hearths and facings, *cast-iron linings*, *metal frames*, *grates*, etc., shall be furnished and set by the *mantel contractor*, under separate contract. The mason shall, however, supply all necessary brick, cement, sand, etc., required for the setting of *tile* in fireplaces and hearths.

Registers and Thimbles.—The *heating* contractor shall provide, and the mason shall set, a vent register in the kitchen chimney breast, at the point indicated. Provide and set a (9-inch) *cast-iron* thimble in the chimney for the furnace flue, the top of this thimble to be (6 inches) below the floor joists. Set, also (5½-inch) *galvanized sheet-iron* stove-pipe thimbles—one in the *laundry*, and one in *each attic bedroom*.

Trimmer Arches and Hearths.—Turn trimmer arches for all hearths, and level up all but that in the kitchen to the top of the floor joists with Portland cement for tiling. Make the bed for kitchen hearths (2¾ inches) below the surface of the finished floor. Furnish and set in the kitchen a *rubbed bluestone* hearth (3 inches) thick, well bedded in *Portland* cement, to show (½ inch) above the finished floor.

Preparation for Tiling.—The carpenter shall prepare for, and the mason shall set, a course of brick *on edge* in *Portland* cement mortar between the joists in the *bathrooms*, filling in the joints with mortar, leveling up the work to within *one* inch of the finished *hall* floor. The *tile* shall be furnished and set by the *mantel contractor*, and the *marble slabs* duly put in place by the *plumber*.

The carpenter shall, while the foundation walls are in course of construction, provide and set the window and door frames, or any other necessary woodwork. The frames shall be set perfectly plumb and must be well bedded. The cheek of the quoin stones and lintels in the mason's openings shall be plastered with a (¼-inch) coat of *Vicat* cement mortar, securing a water-tight joint between the frames and mason work.

Whitewashing.—Cover all brick and stone walls in the cellar, including the inside walls of the dumb-waiter shaft from floor to ceiling, with two good coats of whitewash, composed as follows: *ten* parts of freshly slaked *lime* to one part of *hydraulic Portland* cement. Note, however, that the walls are to be pointed up smoothly by the mason, then allowed to dry, and subsequently brushed down before applying the whitewash.

INSIDE MASON WORK.

15. Up to this point the specifications have described all the mason work required on the building, so far as its erection is concerned, exclusive of inside finish. There should now follow a detailed description of all the inside work called for in the province of the mason, tending towards the finish of the building and the completion of his contract.

LATHING AND PLASTERING.

Lathing.—All walls, ceilings, partitions, and work furred off throughout the building, including the cellar ceiling and dumb-waiter shaft, are to be lathed with sound dry *spruce* laths, unless otherwise specified. These laths shall be put on ($\frac{1}{4}$ inch) apart, with four nailings to each lath, the joints to be broken at every *tenth* lath. Back-lath all walls, nailing the lath to furring strips where the wood wainscot occurs. No laths shall be put on vertically, nor run through behind studs, from one room to another, the plasterer seeing to it that all angles are solidly formed and that the furring is securely nailed before the laths are put on. The *bathroom* walls, back of the *tile* wainscot, shall be covered with *expanded metal lath*, provided and put up by the plasterer. All pockets in partitions, through which heater pipes are run, shall be covered with *expanded metal lath*, provided and put up by the *heating* contractor.

Plastering.—Plaster all walls, ceilings, and partitions over the lathing just described, unless otherwise specified, with *two* coats of mortar, a *scratch* and a *brown* coat, composed of pure, well slaked lime, clean, sharp sand, and best cattle or goat hair, the hair to be well beaten and soaked in water.

Body of the Work.—The scratch-coat mortar shall be mixed in the proportion of *one* barrel of lime, *three* barrels of sand, and *one-half* bushel of hair. The brown-coat mortar shall be mixed in the proportion of *one* barrel of lime, *five* barrels of sand, and *one-quarter* bushel of hair—all to be thoroughly mixed and stacked in the rough, until ready for use. The brown mortar should stand from *one* to *two* weeks, and the scratch mortar *three* days, before being used.

Apply the scratch coat with sufficient force to secure strong clinches, and scratch well with a wooden comb. The scratch coat should not be allowed to dry hard before applying the brown coat. Apply the brown coat, and float to a smooth, even surface, flush with grounds. All ceilings shall be made perfectly level, all walls plumb and true, and all angles sharp. Carry the scratch and brown mortar back of all bases, and back-plaster behind the wainscoting, etc., down to the floor.

King's Windsor Cement Finish.—The plaster frieze in the *first-story hall* between the dado and the wood cornice, as well as the ceiling panels and the side walls of the *vestibule*, shall be plastered *two* coats with (King's Windsor cement) mortar, mixed in the proportions herein specified for outside plastering. Apply a good scratch coat over lath, and comb, and allow the mortar to set well, but not to thoroughly dry. Apply a *second*, or *finishing*, coat of the same mortar, and trowel it down flush with grounds; float off to a perfectly true, even surface, making all angles sharp and the corners plumb and true. These wall surfaces shall *not* be white finished, but shall be *tinted* by the painter.

The walls of the dumb-waiter shaft, down to the under side of the first-story joists, shall be finished with *two* coats of (King's Windsor cement) mortar.

Plaster over metal lath in the bathroom, with a scratch coat of (King's Windsor cement) mortar, and scratch to a rough surface. Finish with a good coat of *Portland cement* mortar troweled down, and left ready for the tile setter.

Finish of Walls.—Finish all plastered surfaces over the brown coat, except in *first-story hall* and *vestibule* and behind wainscoting, with a white, hard-finishing coat, composed of lime putty, fine washed sea sand, and plaster of Paris, carefully applied, and troweled down to a perfectly smooth-polished surface, free from trowel or brush marks, or blemishes. The lime used in the finishing mortar must be well slaked, strained through a fine sieve, and allowed to stand for a *week* in a covered trough or in barrels, to insure perfect slaking.

Centers.—Furnish and set plaster centerpieces, not to exceed (\$2.00) net, each, in all rooms except the *entrance hall*, where drop lights are indicated on the plans. The patterns shall be selected by the *owner*.

Cornices, Etc.—Run a plaster cove on furring—set by the carpenter in the ceiling angles of the *parlor*, *library*, and *vestibule*—with an (8-inch) radius, the cove to finish with a molded member on the wall only. Run, also, a similar cove of (12 inches) radius with wall mold in *dining room*; run, besides, in the *bathrooms*, the *second-story hall*, the *principal bedrooms*, and *dressing rooms*, a cove of (6 inches) radius without moldings. Run a neat plaster *ogee* cap molding ($2\frac{1}{2}$ inches) wide around the walls of the *principal bathroom* over the wainscot tiling.

Arches, Brackets, Etc.—The carpenter shall form the furring required, and the mason shall plaster all arches as indicated. He shall, also, provide and set molded plaster brackets as required by the detail drawings. Where, in any part of the building, the finished

plaster surface meets some other material on the same plane with itself, the place of meeting between the plaster and this other material shall be marked by a ruled line joint.

Plastering on the Outside.—The carpenter shall set ($\frac{5}{8}$ -inch) grounds over sheathing lath, and the mason shall cover the lath over with a good coat of (King's Windsor *neat* cement), mixed in the proportion of one part cement to *two* parts of sharp sand—these to be thoroughly mixed in a dry state, using no other ingredients but just enough water to temper the mixture for easy working. Apply this mortar to the *exterior panels* and *open-timber* surfaces, using sufficient force to secure good clinches; trowel down evenly, and scratch with a wooden comb. Allow this scratch coat to settle and become almost dry before applying the finishing coat. Apply, then, the finishing coat of *Portland* cement, “rough cast,” in the proportion of *one* part cement, *one* part sharp sand, and *one* part fine gravel—the mortar to be colored with *mineral mortar stains of an approved tint*. Bring the finishing coat up with the grounds, and float off to an even surface.

Patching.—Do all the required patching of the plaster work after the other craftsmen have finished their work; repair all damaged plaster and cracks, leaving the work in a first-class condition in all respects and without room for exception.

CARPENTER WORK.

16. Under the general heading of “Carpentry” should be included all the work on the building pertaining to the woodworking trades. If the carpenter is to include in his contract all the necessary cutting of beams, floors, and other parts of the woodwork, to enable the other contractors to run their pipes, wires, etc., this should be clearly stated in the beginning.

As under the head of “Masonry,” it is usual to include in the first part of the specification of carpenter work all the descriptions of the quality or grade of material to be used throughout the job, and then to describe in detail the requirements of the general rough framing and outside work.

The carpenter shall do all the cutting of timber and such other woodwork as may be required by the other crafts for the due execution of their work.

Framing.—The sills shall be halved at the corners, bedded in *Vicat cement* mortar, and set perfectly level. The corner posts shall be set plumb, to a line, and well braced while the other framing is in course of erection. The girths and ties shall be mortised and tenoned into the posts and pinned with *oak* pins. The floor joists and other important timbers shall be so framed that it may not be necessary to cut them for pipes or chimneys. All framing must be kept at least (2 inches) clear of the chimneys. The floor joists shall, in every case, run to within ($\frac{1}{2}$ inch) of the sheathing boards.

All headers and trimmers around stair wells and chimneys shall be of joists, doubled and spiked together, or shall be in one piece, 4 inches thick, hung in *wrought-iron* stirrups ($\frac{1}{2}$ in. $\times$ 2 in.), let in flush with the top of joists. In framing the roof around chimneys, the trimmer rafters and headers shall be doubled and securely spiked together. All joists shall be placed with their crowning edge upwards, and have a bearing of at least (4 inches) on the sills and be well spiked thereto. The studs in the exterior walls shall rest on the sill, be securely spiked thereto, and to the floor joists as well.

Trussed Partitions.—Truss all carrying partitions not resting directly on the sills, or on a wall or girder, with (4 in. $\times$ 8 in.) *spruce*, well framed together and transmitting the weight to posts (4 in. $\times$ 6 in.), resting on the sills or girder, or, if in the second story, on a supported partition below. Truss over all openings (4 feet) or more in width.

Partitions.—Build the partitions as shown on the plans, setting them straight and plumb. The partitions over walls and girders shall run down to these, instead of resting on top of the joists. All other partitions shall have sills, as hereinbefore specified. Make the corners and angles solid by blocking and spiking two studs together. The pockets of sliding-door partitions shall be sheathed with ($\frac{5}{8}$ in. $\times$ 3 in.) tongued-and-grooved *white pine*, *painted on both sides* before being put on; form guides for door-hanger track, and set these perfectly level and to a line. Provide all openings in the cellar wall with rough wood lintels not less than (4 inches) thick. These lintels shall, at their ends, have, at the least, a (4-inch) bearing in the walls. Provide all templets or forms required for brick arches.

Timber.—All timber, unless otherwise specified, shall be of *spruce*, well seasoned, sound, free from dry rot or other defects and imperfections. The principal timbers shall be of the following dimensions:

(1) **Girders** (8 in. $\times$ 10 in.), *Georgia pine*. (2) **Sills** (3 in. $\times$ 8 in.), laid flat. (3) **Posts** (4 in. $\times$ 6 in.), having a continuous (2 in. $\times$ 4 in.) scantling spiked on one side from the sill to the plate, placed at all angles and corners of the buildings. (4) **First and second story**

Joists (3 in. $\times$ 10 in.), spaced (16 inches) on centers. (5) **Attic floor joists** (3 in. $\times$ 8 in.), spaced (16 inches) on centers. (6) **Headers and trimmers** (4 inches) $\times$ the depth of joists, or joists doubled. (7) **Collar beams** ($1\frac{1}{2}$ in. $\times$ 10 in.), well nailed on every *second* pair of rafters. (8) **Plates and ties** (4 in. $\times$ 6 in.). (9) **Girths** (4 in. $\times$ 6 in.). (10) **Ledger boards** (1 in. $\times$ 6 in.), notched (1 inch) into studs and posts, and well spiked at every bearing. (11) **Studs** (2 in. $\times$ 4 in.), *hemlock*, spaced (16 inches) on centers throughout. The door and window openings, including door openings in partitions, shall have *two* (2 in. $\times$ 4 in.) studs from the floor to the head; the heads to be formed in like manner. (12) **Partition sills and plates** (2 in. $\times$ 4 in.), *doubled and spiked*. (13) **Rafters** (2 in. $\times$ 8 in.), spaced (16 inches) on centers. (14) **Hip rafters and ridges** (2 in. $\times$ 10 in.). (15) **Valley rafters** (3 in. $\times$ 10 in.).

The veranda, porte-cochère, and porch timbers shall be as follows:

(1) **Sills and cross-sills** (4 in. $\times$ 8 in.). (2) **Floor joists** (3 in. $\times$ 8 in.), cut in between and set (20 inches) on centers. (3) **Ceiling beams and rafters** (2 in. $\times$ 6 in.), set (20 inches) on centers. (4) **Hips and valleys** (3 in. $\times$ 8 in.). (5) **Plates**, *two* pieces (2 in. $\times$ 10 in.) *spiked* together. Provide and set, likewise, all other timber required to fully complete the work.

Bridging.—Bridge floor joists on every floor with *one double* row of ($1\frac{1}{2}$ in. $\times$ 3 in.) *cross-bridging* to each span (10 feet) or over, and *two double* rows to all spans (15 feet) or over; all to be cut in and nailed at each end with *two* 10d. nails.

All outside walls and inside partitions shall be bridged *once* in their height with pieces (2 in. $\times$ 4 in.), cut in *diagonally* and nailed at each end with *two* 10d. nails.

Put in (2 in. $\times$ 4 in.) pieces horizontally between the studs in the *bathroom* partition, (12 inches) apart, to a height of (4 feet) above the floor to afford extra support for the metal lath.

Grounds, Furring, Etc.—Cross-fur the ceilings of veranda, porte cochère, and porch, with (1 in. $\times$ 2 in.) *spruce* furring strips placed (16 inches) on centers.

Fur all chimney breasts where pressed brick or tile facing does not occur, with (1 in. $\times$ 2 in.) *spruce*, well nailed to the chimneys and spaced (16 inches) on centers. Nail (1 in. $\times$ 2 in.) furring strips on the sides of studs where the wainscot occurs, for back plastering.

The side walls in the *hall* and *vestibule* shall be furred *vertically* on studs with (1 in. $\times$ 2 in.) *spruce* strips for plastering. Set furring strips (2 inches) wide, *one* at the floor, and *one* half way up for all wainscotting, except that in the *bathroom*.

For the molded cap over the dado, and for the wainscot cap in the *vestibule*, set a (2 in. $\times$ 4 in.) furring strip, to be rabbeted for dado and

plaster; also set furring for wood frieze, cornice, and plaster panels on the ceilings. Put up (2 in. $\times$ 4 in.) furring for false beams, well framed together, set to a line and hung from joists above.

Prepare the *principal bathroom* for floor *tiling*, and the *servants' bathroom* for *marble slabs*, by laying ($\frac{7}{8}$ in. $\times$ 4 $\frac{1}{2}$ in.) tongued-and-grooved boards on (1 in. $\times$ 2 in.) cleats, nailed to the floor joists. The boards shall be laid tightly and well nailed, to finish (5 inches) below the level of the top of joists in the *hall* or adjoining rooms.

Rough Flooring.—Lay an under floor throughout the first and second stories of ($\frac{7}{8}$ in. $\times$ 6 in.) tongued-and-grooved *spruce*, surfaced on one side, laid *diagonally* on the joists, and *top* nailed at every bearing with *two* 8d. nails. Run this flooring closely around all studs and up to the outside sheathing boards, breaking the joints on the joists only; never between. Provide and set suitable nailing pieces between the joists and studs to take the ends of the flooring. Lay the attic floor with ($\frac{7}{8}$ in. $\times$ 6 in.) *spruce*, of the same stock as that used for the under flooring in the other stories, selecting the best on the ground for the purpose. This floor must be well driven together, *blind* nailed to every bearing, fitted closely around all studs, and run up to the sheathing.

Sheathing.—Cover the entire frame of the building in the first story with ($\frac{7}{8}$ in. $\times$ 6 in.) tongued-and-grooved *North Carolina pine*, surfaced on one face to a uniform thickness, put on *diagonally*, making joints only on studs, and breaking these joints; secure the covering with *three* 8d. nails to every bearing.

Sheathing Lath.—Cover the frame from the belt line at the second-story floor to cornice and into gables, as well as the faces of dormer windows, with ($\frac{7}{8}$ inch) *Byrkit-Hall pine* sheathing lath, having edges tongued and grooved. Put on horizontally and secure with 8d. nails.

Sheathing Paper.—Cover the frame over the sheathing boards up to the second-story level, with *heavy-weight resin-sized felt paper*, laid with a (3-inch) lap and tucked under sheathing lath, against studs and under all corner boards, casings, etc.

Roofs.—Cover all the roofs and dormers with (1 $\frac{1}{4}$ in. $\times$ 3 in.) *spruce* shingle lath, laid on roofs with about (2 inches) space and on cheeks of dormers with about (1 $\frac{1}{2}$ inches) space between. The foot of all roofs along the gutter line, all valleys, hips, and ridges shall have a (1 $\frac{1}{4}$ in. $\times$ 10 in.) board nailed on with *three* 10d. nails to each bearing.

Shingles.—Cover the roof with XXXX *sawed cedar* shingles (18 inches long and none less than 3 inches in width), laid on (5 inches) to the weather and secured with at least *two* 4d. cut nails to each shingle. Cut the shingles to a line along valleys and hips, and cover all hips and ridges with a capping course known as *Boston hips*.

The shingles on the face and checks of dormers shall be of uniform width, and laid ($4\frac{1}{2}$ inches) to the weather. The valleys shall be (4 inches) wide. All shingles shall be *dipped* by the *painter* and allowed to dry before being put on.

The carpenter shall see to it that all flashings of valleys, hips, etc. have been, as specified under *tinner's work*, properly laid before placing any shingles in position.

OUTSIDE FINISH.

17. The work to be done on the outside of the building should be grouped under one general subheading, in order that it may be easily picked out in looking over the specifications.

All outside finishing, lumber, moldings, etc. shall be, unless otherwise specified, of clear *white pine*, which shall be worked to conform to scale and detail drawings, and as soon as practicable after having been placed in position, primed by the painter.

Cornices.—Form the main cornices with ($1\frac{1}{8}$ -inch) *facia*, (1 in. $\times$ 4 in.) crown molding, ($1\frac{1}{8}$ -inch) *plancier*, etc. to conform to details. Support the cornices with ($1\frac{1}{4}$ -inch) rough *spruce* brackets, spaced (2 feet 8 inches) on centers and securely nailed to the frame. Form the gutters with ($1\frac{1}{8}$ -inch) boards, laid with the proper grade to the points indicated for leaders.

Barge Boards.—Finish the front of main gables with (2 in. $\times$ 10 in.) plank, dressed, chamfered, and finished as indicated.

Open Timber Work.—The open timber staves shall be ($\frac{7}{8}$ inch thick, and from 4 inches to 6 inches wide), *clear white pine*; all joints to butt; end pieces to be rabbeted ($\frac{1}{2}$ inch) under the points where they are jointed to another piece. The method of jointing and other details of open timber work are clearly indicated on the detail drawings. All open timber work shall be painted on the back before being set in place.

Water-Table, Etc.—The water-table shall be ($1\frac{1}{4}$ in. $\times$ 8 in.), having a ($1\frac{1}{4}$ in. $\times$ $2\frac{1}{2}$ in.) cap with a ($\frac{1}{4}$ -inch) tongue on its upper edge, and finishing with a (1 in. $\times$ $1\frac{1}{4}$ in.) *ogee* bed mold.

The belt between the clapboards and open timber work shall be ($1\frac{1}{2}$ in. $\times$ 8 in.), the under side to have a ($\frac{1}{4}$ -inch) rabbet, ($1\frac{1}{4}$ inches) deep for clapboards. Finish with a (2 in. $\times$ $2\frac{3}{4}$ in.) beveled cap and (1 in. $\times$ $1\frac{1}{4}$ in.) bed mold. Put up ($1\frac{1}{8}$ in. $\times$ 6 in.) corner and angle boards scribed to the water-table cap, etc.

Siding.—Cover the frame, as shown on the drawings, with (*No. 1 clear white-pine beveled siding*) (6 inches) wide, laid ($4\frac{1}{2}$ inches) to the

weather, and nailed to every bearing with 6d. cut finishing nails. All joints shall be made on the studs only. Cut close, neat joints against all window and door frames, corner boards, etc. In all panels (18 inches) or under, the clapboards shall be put on in one piece, and no butt joints to appear in the first course over the window and door frames.

Veranda, Etc.—The veranda, porte cochère, and porch shall be constructed as indicated on the scale and detail drawings. Lay the floors with ($1\frac{1}{4}$ in. $\times$ 3 in.) tongued-and-grooved *clear white pine*, blind nailed to every bearing, having the joints bedded in *white lead* and well driven up. The flooring shall be laid at right angles to the building and run full up to the sheathing. Work a rounded nosing on the edge of the veranda and porch floors. Run a ($1\frac{1}{4}$ in. $\times$ 6 in.) skirting board around, and finish under the nosing with a bed mold. Construct the steps with ($1\frac{1}{4}$ -inch) treads and ($\frac{7}{8}$ -inch) risers; finish steps with a rounded nosing and bed mold; the full dimensions are indicated on the plan.

The columns on the veranda and porte cochère shall be of *cottonwood* (10 inches) in diameter *in one piece*, turned, and having a plinth block with turned base and cap. The posts for the porch shall be (6 in. $\times$ 6 in.), chamfered and molded as indicated. Bore a ($1\frac{1}{4}$ -inch) hole through the columns for their entire length.

The top rail shall be molded and built up; the bottom rail to be solid, with beveled top and molded edge, as indicated. The balusters on the front of the building shall be ($1\frac{1}{2}$ inches), turned, and set ($3\frac{1}{2}$ inches) on centers; those for the porch to be ($\frac{7}{8}$ in. $\times$ $1\frac{1}{2}$ in.), set (2 inches) on centers.

Construct strong lattice frames to be placed along the front of veranda, port cochère, and porch, to be constructed of ($1\frac{3}{8}$ in. $\times$ $3\frac{1}{2}$ in.) sides and top rail, and ($1\frac{3}{8}$ in. $\times$ 5 in.) bottom rail, all mortised and framed together; the slats to be ($1\frac{3}{8}$ in. $\times$ $1\frac{3}{8}$ in.), spaced ($3\frac{3}{4}$ inches) on centers, and halved together at each intersection in a proper manner.

Ceiling.—Put up the veranda, porte-cochère, and porch ceilings level, with ($\frac{1}{2}$ in. $\times$ $3\frac{1}{2}$ in.) tongued-and-grooved *clear North Carolina pine*, center beveled, the joints neatly fitted. Blind nail with 6d. finishing cut or steel wire nails; the ceiling to run at right angles with the front of the building.

Temporary Privy.—The mason shall excavate for, and the carpenter shall erect, as soon as work is commenced on the premises, a temporary privy at the rear of the lot, for the use of the workmen. The carpenter shall, at the completion of the work, remove the privy, and the mason shall clean out and fill the vault with fresh earth.

Clothes Posts.—Provide and set *four* (5-inch) *turned locust* clothes posts in the rear yard, at the points directed. The posts shall

be (8 feet) above ground and (3 feet 6 inches) below the surface; the lower part of the posts under grade to be left in the rough and stripped of the bark. Finish the posts with a ball turned on top and provide with *two* cross-pieces of *oak* ($1\frac{1}{4}$ inches) in diameter to run through the post.

Fences.—Construct a picket fence along both sides of the lot (4 feet) high. Set up (5-inch) *squared and surfaced chestnut* posts (6 feet) apart; run between the posts *two* (2 in. $\times$ 4 in.) surfaced *white-pine* rails. The pickets shall be ($1\frac{3}{8}$ inches) square, pointed on top and spaced (2 inches) apart; run a ($\frac{3}{8}$ in. $\times$ 10 in.) surfaced *white-pine* base-board with ($\frac{3}{8}$ in. $\times$ 2 in.) beveled cap, and finish with ($1\frac{1}{2}$ -inch) molded *white-pine* ribbons. The side fences at the front end shall, as indicated, be finished with a boxed post on top of the terrace slope. The rear fence shall be (4 feet) high with (5-inch) *square surfaced chestnut* posts, set (6 feet) apart, with rails, baseboard, and ribbons, the same as on the side fences. The pickets shall be ($\frac{7}{8}$ in. $\times$ $2\frac{1}{2}$ in.), *round pointed on top*, and spaced ($2\frac{1}{2}$ inches) apart.

INSIDE CARPENTER WORK.

18. Having completed the specification of all the work and material for the rough part of the structure, there should follow the details of all the inside woodwork, generally termed “Interior Finish.” The specific difference between these two divisions of the carpenter’s contract is the distinction between carpenter work and joiner work as set forth in the sections on *Carpentry* and *Joinery*.

INTERIOR FINISH.

Finished Floors.—The upper or finished floors in the first and second stories shall not be laid until the plastering is completed; nor shall the material thereof be brought upon the premises until ready for laying, unless provision is made for its due protection from dampness, injury from lime, etc.

When the plastering has been entirely completed and the building thoroughly cleaned out, the carpenter shall lay *heavy-weight felt, resin-sized paper*, with a (3-inch) lap over the entire first and second story floors, except in the principal bathroom—the paper to run up to the partition walls on all sides of the rooms.

Lay over the paper a ($1\frac{1}{8}$ in. $\times$ 2 in.) tongued-and-grooved, *quartered white-oak* floor throughout the first story, well driven together and blind nailed. Lay the floor in the second story of ($\frac{7}{8}$ in. $\times$ 2 in.)

tongued-and-grooved, *comb-grained Georgia pine*, in like manner; fit the flooring neatly around floor registers, etc. All the stock in finished floors must be thoroughly kiln-dried and selected.

Cover the floors, as soon as laid, with a layer of heavy felt building paper, to protect them from heel marks and paint spots till the time arrives for finishing the floors. Before the last coat of paint or varnish is applied to the trim, etc., the carpenter shall plane down the floors of the first and second stories. He shall, besides, scrape and sandpaper the floor in the principal rooms of the first story and of all halls.

Window Frames.—All shall be made in accordance with the scale and detail drawings. The frames for masonry openings shall be boxed, as shown, with (2½-inch) *white-oak* sills, (1½-inch) casing, (1½-inch) blind hanging stile, (1½-inch) pulley stiles and heads, (¾ in. × ½ in.) parting strips, and (¾-inch) back lining.

The frames for double-hung sash in *first story* shall have (2-inch) sills rabbeted for siding, and (1-inch) subsills, (1½ in. × 4 in.) molded outside casings and heads with cap, (¾-inch) blind hanging stiles, (1½-inch) pulley stiles and heads, and (¾ in. × ½ in.) parting strips. The pulley stiles and parting strips for all double-hung windows shall be of clear *Georgia pine*, coated with *raw linseed oil* before leaving the shop. The frames shall have (1½-inch) steel axle pulleys with face plates to match other hardware of the sash. The frames for hinged sash shall have (1½-inch) rabbeted jambs and heads, with outside casings and blind hanging stiles, the same as the other frames. The window frames in the cellar, except those shown as double-hung, shall be constructed of (2 in. × 6 in.) *pine*, rabbeted for sash, and have (2-inch) *white-oak* sills, the sash to be hinged *on top*.

Sash.—The sashes for the first and second stories shall be (1½ inches) thick; those for the *first and second story halls* shall be constructed of selected, clear, straight-grained *cherry*. The sashes for the *dining room* and *library* shall be of selected *comb-grained white oak*. All hard-wood sashes shall, before leaving the shop, be primed with paint on the outside. All other sashes in the first and second stories shall be of clear *white pine*.

The cellar and attic sash shall be constructed of clear *white pine* (1½ inches) thick. The upper sash of all double-hung windows shall have horns worked on the lower end of the stiles, as indicated on the details. All *pine* sashes which are to be painted shall be primed before leaving the shop. The sashes shall be well framed, mortised together, and pinned, and of a uniform thickness as specified.

Blinds.—Provide and hang blinds on all windows in the first story, the second story, and attic, except as otherwise indicated on the drawings. The blinds shall be made of (1½-inch) clear *white pine*, with rolling slats secured to rods with *copper* staples. The blinds on

wide windows—where shown—shall be *fourfold* with suitable *adjustable* fastenings. All blinds shall be hung with *wrought-iron L* hinges and have suitable catches on the walls of the building and on window sills. All blinds shall be primed with *white-lead and linseed-oil* paint, before being brought on the premises.

Door Frames.—The frame of the outside cellar door shall be constructed of (2 in. $\times$ 8 in.) *pine*, rabbeted for door, and shall have a ($2\frac{1}{2}$ -inch) *white-oak* sill. The frame shall be solidly blocked away from the masonry jambs and well spiked to the wood plugs driven into the walls. The inside cellar door frames and outside first-story door frames shall be of ($1\frac{1}{4}$ -inch) *white pine*, rabbeted for doors. All inside door jambs in the first story, second story, and attic shall be ($1\frac{1}{2}$ -inch) rabbeted for doors, those for halls to be of clear *cherry*, for *dining room* and *library* of *quarter-sawed white oak*. The jambs for all other inside doors shall be of clear *white pine*, those for sliding doors ($\frac{3}{8}$ -inch) to match the finish of the rooms.

Doors.—All doors shall have raised panels molded to conform to the scale and detail drawings. The stock for all doors must be kiln-dried and free from sap or other defects. The *front* door shall be of *white pine* ($2\frac{1}{2}$ inches) thick, and the *vestibule* door ($2\frac{1}{4}$ inches) thick; the doors from *hall* to *parlor*, *dining room*, and *library*, and from *parlor* to *dining room* shall be (2 inches) thick; all other doors in the first and second stories shall be ($1\frac{3}{4}$ inches) thick, except closet doors, which shall be ($1\frac{1}{2}$ inches) thick. The outside cellar door shall be ($2\frac{1}{4}$ inches) thick; the inside cellar doors ($1\frac{3}{4}$ inches) thick; all the doors in the attic ($1\frac{1}{2}$ inches) thick.

All doors shall be constructed of wood to correspond with the finish of the rooms. The doors in the principal rooms of the first story, including *hall*, and the *hall* of the second story, shall have *white-pine built-up cores* and ($\frac{1}{4}$ -inch) *veneering*, all well glued up. Put ($\frac{1}{4}$ -inch) *pine veneer* on all doors that are to be *hard-wood veneered* on one side only; put *pine veneer*, also, on the inside of closet doors of rooms finished in hardwood.

Dutch Door.—The vestibule door shall have a horizontal rabbeted joint at the center, with striking pieces of *cherry* rabbeted and glued up to the core, the top of this door to swing in first.

All door panels wider than (8 inches) shall be built up, the grain and color of the wood matched; all shall be well jointed and glued together. The sliding doors shall have an astragal joint with hard-wood striking pieces. Construct all the necessary doors to the *dumb waiter*, *cupboards in pantry*, *kitchen*, etc. for *electric boxes*, etc., required or indicated, all to conform to detail drawings.

Saddles.—All doors, except sliding doors, shall have ($\frac{5}{8}$ -inch) molded, *quartered-oak* saddles, well fitted around base, jamb, and plinth blocks.

Inside Trim and Base.—All windows and doors throughout the building, except in the cellar, shall be trimmed to conform to the detail drawings.

The halls in the first and second story shall be finished in selected clear *cherry*; the *dining room* and *library* in clear *quarter-sawed white oak*. All other rooms, closets, etc. shall be finished in clear *white pine*, unless otherwise specified. The trim in all the principal rooms in the first story, second story, and attic, including the halls, shall be (5 inches) wide, molded as shown on details. The trim in closets and inferior rooms shall be ($\frac{7}{8}$ in. $\times$ 4 in.) with plain mold on the jamb side. This mold shall be mitered and the body of the trim butt jointed. All door trim shall stop on the molded plinth blocks at the same height as the base. The back band and molding on the trim shall be mitered, and the *facia* jointed on a horizontal line.

All the windows in the principal rooms shall have molded panels below the stool; all other windows shall have stools and aprons molded to details. The base in the first story shall be ($\frac{7}{8}$ in. $\times$ 8 in.); that in the *kitchen* and *pantry* to be *beveled* on top. The base in the second story and attic shall be ($\frac{7}{8}$ in. $\times$ 6 in.), the *closet* base ($\frac{7}{8}$ in. $\times$ 6 in.), with *beveled* top. All bases shall be scribed to the floor. Where the base mold does not stop against the back band of the architrave, it shall have a return *worked on*.

Wainscoting.—Construct and panel the wainscoting as required by the detail drawings. The wainscot in the hall shall have a molded cap member to be coped in angles and mitered on corners. The dado shall be of the same altitude as the door architraves; the hall wainscot shall be continued up the stairs, rail high, continued around the second-story hall (3 feet 2 inches) high, up the attic stairs and around the attic hall (3 feet 2 inches) high.

All paneled wainscoting shall be ($1\frac{1}{8}$ inches) thick, the end stiles of each section extending down to the floor; and in long sections, *one* intermediate stile, at least, shall be carried to the floor. The wainscot in the *vestibule* shall be (4 feet) high. All hard-wood wainscot, before leaving the shop, shall be given a good coat of *pure raw linseed oil* on the reverse side.

Ceiled Wainscot.—Put up ($\frac{5}{8}$ in. $\times$ 2 in.) *beveled* tongued-and-grooved *white-pine* wainscoting, (4 feet) high, in *laundry*, *kitchen*, and *pantry*, finishing it with a molded cap and scribing it down on the base as required.

Wood Cornice, Beam Casing, Etc.—The frieze and cornice in the *hall* shall be of *cherry*, molded as required by the detail drawings. Case up the false ceiling beams, forming panels on ceiling, and continue the casing around the walls as well; set the bed molding and fit all neatly together. The flat surfaces of the panels shall be plastered.

Columns and Screen.—Build up the pedestals for columns with (1½-inch) stiles and rails, panel to correspond with the wainscot; finish with top (1½ inches) thick, on a line with the wainscot cap, the edge to be molded and finished with an *ogee bed* molding. Build up plinths for columns of the size shown, and veneer these plinths to cover all end wood. The base and abacus shall be molded and the cap hand carved, as shown on the full-size details. The shafts shall be built up on a *pine* core, with *seven* vertical pieces of *cherry* (1⅞ inches) thick, and shall be glued up and matched as to the grain and color of the wood. The shaft shall be turned to the proper entasis, and the flutes worked to a uniform width and depth. The spindles shall be (1½ inches), turned and spaced as indicated.

Hall Seats.—Construct the seats in the hall, library, and dining room as indicated, to have, as required by drawings, paneled fronts and ends, the tops hinging at the back. Line the inside with (½ in. × 2 in.) matched *white pine*.

Bookcases.—Set up bookcases in the library; to be built of *quartered white oak*, to the dimensions given, the ends to be (1½ inches) thick, and paneled. Make the doors (1⅓ inches) thick, with rabbeted joints, and hinge; glaze with best clear *French plate* glass.

The cases shall have a molded cap and (1½-inch) top with the edge molded as shown. The shelves shall be of clear *maple* (⅞ inch) thick, with a (¼-inch) molded *oak* front edge, glued on. Frame the backs of *maple*, with (⅞-inch) stiles and rails, and (½-inch) flush panels.

Carving, Composition, Etc.—Execute all carving as required by the drawings. All wood for carving shall be formed in the solid, matched as to color, and glued up, the carving to be done by hand. The finer lines of the carving shall be cut only after the work has been finally set in position.

The painter shall provide and set in place the composition ornaments as indicated on the drawings. The work on these ornaments shall be executed by a skilled modeler, strictly according to details, and the ornaments themselves set in position by a competent mechanic.

Picture Moldings.—Provide and erect the following:

(a) For parlor: a (⅞ in. × 1⅓ in.) mold of *white pine*, with *composition* pearl and bead planted on. (b) For dining room and library: a (⅞ in. × 1½ in.) *quartered-oak* mold to match the trim of rooms. (c) For all

bedrooms in the second story: a ($\frac{7}{8}$ in. $\times$ $1\frac{1}{2}$ in.) *enriched gilt* molding.
(d) For other bedrooms: a ($\frac{7}{8}$ in. $\times$ $1\frac{1}{4}$ in.) *plain gilt* molding.

All picture molding, except that perfected in gilt, shall, with the exception of the last coat, be finished by the painter before being put in place. It shall, likewise, be level and straight, and coped over the back band on trim.

Angle Beads.—Cover all plaster corners in the building with ($1\frac{1}{4}$ -inch) turned angle beads (4 feet 6 inches) high, having turned and molded ends. All angle beads in rooms finished in hard wood shall be of the same material as the finish of the rooms; all others shall be of hard wood, finished to match other work.

STAIRS.

19. It is seldom that the contracting carpenter attempts to build the stairs for a building in his own shop. He usually entrusts this part of the work to some one who makes stair building his special vocation, and for this reason it is advisable to include all stair work under a separate heading.

Main Stairs.—Construct the main flight of stairs as indicated; the rough stringers to be (3 in. $\times$ 8 in.), and all stringers, platforms, and landings to be well framed together. The front strings shall be closed with a molded cap and paneled as indicated. All treads shall be ($1\frac{1}{4}$ inches) and risers ($\frac{7}{8}$ inch), tongued and grooved together, glued and wedged up; the treads, risers, and all platforms to be of *quartered white oak*. The treads shall have a molded nosing finished with an *ogee* bed mold. The wall strings shall be molded to correspond with the base. Panel the sides of the main flight down to the floor, and, likewise, under the rake and soffits with molded panels, to correspond with those on the wainscot and dado in the hall. The newel at the foot of the main flight shall be (7 inches) square, of *cherry*, boxed, paneled, molded, and carved as indicated. All other newels and posts of the main stairs shall be (5 inches) square, boxed, and finished in like manner.

The second-story flight to attic shall have closed strings with molded cap and paneled sides; rakes and soffits to be the same as in the main flight. All drop newels shall have molded and carved drops. The rails shall be (3 in. $\times$ 4 in.), built up, molded, and bolted together at the easements, and to all posts and newels. Each piece of rail shall be matched in color, straight grained, and have casements or ramps at all newels and posts. The balusters shall be of *cherry* ($1\frac{1}{2}$ inches), matched

as to color, to have square butts, and be *turned* and set *three* to each tread.

Rear Stairs.—The rear stairs from the first story to attic shall be strongly built with (2 in. $\times$ 6 in.) stringers and platform framing, and shall have ($1\frac{1}{4}$ -inch) treads and ($\frac{7}{8}$ -inch) risers, tongued, grooved, and wedged together, as well as housed into the stringers. The treads shall have a rounded nosing with a cove fillet under it. The wall strings shall be ($1\frac{1}{4}$ inches) thick, molded to correspond with the adjoining base. The treads, risers, and platforms shall be of clear, selected *North Carolina pine*. The outside stringers are to be finished with a mold. The soffits of rakes and platforms shall be furred for plastering. The rails shall be (2 in. $\times$ 3 in.) of straight-grained *white oak*, molded as indicated. They shall have easements at the lower ends of rake sections, and shall be bolted together, and to the newels and posts as well. The balusters shall be (1 in. $\times$ $1\frac{3}{8}$ in.), *three* to a tread. Sandpaper the corners, and dovetail the lower end of balusters to the treads, covering the joint with a nosing planted on, and mitering with, the nosing on the front of the treads. The newels and posts shall be (4 in. $\times$ 4 in.) *solid white oak*, chamfered, and the top molded, as shown on the detail drawings.

Cellar Stairs.—Construct strong plank stairs to the cellar; the stringers to be (3 in. $\times$ 10 in.) of dressed *spruce* plank; the treads to be ($1\frac{1}{4}$ -inch) and the risers ($\frac{7}{8}$ -inch) *North Carolina pine*, housed into both strings and tongued and grooved together. Place a (4-inch) square, *solid oak* post at the foot of this flight. The upper rail shall be (2-inch) round *oak*, let into and bolted to the newel; the intermediate rail to be ($1\frac{1}{2}$ in. $\times$ 3 in.) *North Carolina pine*—all to be well framed together and strongly built.

20. To avoid confusion or misunderstanding in the selection of stock mantels, or such other fixtures as are manufactured in numerous designs and at various prices, an amount limiting the prime cost of each is usually stated in the specification in a way to be at once fair to the owner and the contractor. The mantels are often omitted from the specifications entirely, because, generally speaking, at the time the contract is signed, few, if any, of the detail drawings are prepared; or they are made the subject of a separate contract, the owner selecting designs from the manufacturer's stock, or requiring them to be especially designed by the architect. The same conditions apply also to gas fixtures, etc.

MANTELS.

The mantels shall be executed from designs furnished by the architect, or selected from the manufacturer's stock. The carpenter shall fit his work to the mantels in a manner productive of workmanlike results.

The mantel contractor shall furnish and set the mantels, *tile* hearths, facings, etc. (See specifications under "Masonry," Art. 12.) He shall also furnish and lay a *marble mosaic* floor in the *principal bath-room*; a *marble* base (9 inches) high and ($1\frac{1}{4}$ inches) thick; and a *Minton tile* wainscot (3 feet 9 inches) high, to finish with a molded *plaster* cap, run by the mason. The *mosaic floor* shall be set in and the joints grouted with *Portland cement* mortar; this floor shall be laid perfectly level, and the joints between the pieces kept to a uniform width. These joints shall be so well broken that no straight lines shall be visible. The body of the floor *mosaic* shall be of *white Italian* marble, the border (6 inches) wide of *brown Numidian* marble, the base of *dark Siena* marble, with the upper edge rounded.

CLOSETS, ETC.

Dumb Waiter.—The dumb-waiter shaft shall be framed perfectly plumb, the framing to be (1 inch) back of the line of the brick shaft in cellar, that the finished plaster in the shaft may come on a line with the face of the brickwork. Form a box for the weight and properly set the guides, attaching the face board of the weight box with screws. Frame *two* (4 in. $\times$ 8 in.) *dressed Georgia pine* timbers in the closet above attic floor to support the sheaves and mechanism, and set a suitable hinged door with all hardware for access to the shaft.

Provide and put in place a car (22 in. $\times$ 24 in.) and (3 feet 6 inches) high, with an *adjustable hinged* shelf in the center. This car shall be constructed of *oak* and strongly made, guaranteed to carry (1,000 pounds), and provided with all ropes and other appliances complete.

Closets.—Fit up the *butler's pantry* with a counter shelf (2 feet 3 inches) wide, of ($1\frac{1}{4}$ -inch) *white pine*, placing the shelf (2 feet 8 inches) above the floor. Put in cupboards with shelves, and ($1\frac{1}{4}$ -inch) sash doors, hinged, glazed with double-thick *American sheet* glass, and divided as indicated. Construct below the counter shelf *eight* drawers; the upper drawers to be divided for knives, forks, etc. Construct, also, closets, with hinged panel doors and one shelf. The cupboards shall be of the same altitude as the door trim, and finished with a neat crown molding. Fit the *pantry* sink with a ($1\frac{1}{4}$ -inch) grooved *oak* drip board; finish below the doors and drawers, making all conform to the detail drawings.

Kitchen Closet.—Fit up the kitchen closet as shown, with a (1½-inch) counter shelf (2 feet) wide. Erect *five* (¾-inch) shelves over the counter, and continue these around the closet. Support the shelves on (1 in. × 2 in.) cleats and with a (1½ in. × 1½ in.) standard at each corner. Divide the space under the counter shelf and hang the doors as indicated. To give access to barrels, hinge the end of the counter at the back; put in position, also, suitable hooks for pots, etc., as specified under "Hardware."

Provide the *laundry* closet with a counter shelf (20 inches) wide, with *two* drawers below, and erect *four* shelves above.

Linin Closet.—This closet shall have *six* large drawers (16 inches) deep, below the counter shelf; the counter shelf to be (1¼ inches) thick and (24 inches) wide, and extending around *three* sides. Build up *five* shelves (16 inches) wide above the counter, those on the sides to be enclosed with (1¼-inch) sash hinged doors, and (¾-inch) *pine* framing, constructed like the cupboards in the butler's pantry; the shelves at the end of the closet to be open. Finish with a neat cap molding on line with the top of the door architrave.

Dressing-Room Closets.—The clothes closets in the *dressing rooms* shall be fitted up with *three* long drawers (16 inches) deep, below the counter, and with *four* shelves above it, enclosed with paneled, hinged doors (1½ inches) thick. The clothes-hanging closets shall have *two* drawers near the floor and *one* shelf at a point (15 inches) below the top of the doors, which are to be paneled, hinged doors. Put in a (1½-inch) *polished brass-pipe bar* for the support of clothes hangers, the *bar* secured to a socket at each end, as shown on the detail drawings. The hangers shall be furnished by the owner. Provide all bedroom closets, unless otherwise specified or indicated, with *two* drawers, a counter and one shelf above. The closets in the attic shall be fitted up in like manner. All closets shall, where practicable, have a neat clothes-hook strip with *bronze* hooks, spaced not more than (12 inches) on centers.

Wardrobes.—Construct and set in the *three* bedrooms not having built-in closets, wardrobes of *white pine*, with *two* drawers below, a (¾-inch) shelf (15 inches) below top of door, and a clothes-hanging strip with *bronze* hooks. The doors shall be paneled and hinged. Finish with a cap to come on a line with the architraves of the room doors. The backs shall be *ceiled* with (¾ in. × 2 in.) matched *white pine*, and the lower part of the sides cut to fit over the base. Each wardrobe shall have *four brass* casters with (1-inch) hard-wood or composition rollers. Provide the coat closet under the main stairs with a (¾-inch) shelf and a hook strip with *bronze* hooks to conform to the other work.

Pipe Casing, Etc.—Case up all plumbing pipe lines above the cellar with ($\frac{7}{8}$ -inch) boards of the same material as other woodwork wherein such casing is required. The fronts shall be removable and secured in place with *round-headed* screws. Secure the pipes where exposed to view to tack boards with molded edges. Do all the fitting of water-closet covers or seats, or any other fitting of woodwork required by the other trades. Provide and hang in each bathroom, where directed, a neatly molded *oak* strip with *four* bronze clothes hooks. Fit hard-wood beveled borders (2 inches) wide, mitered on corners, around all hearths.

Provide and set at the kitchen sink a ($1\frac{1}{4}$ -inch) *oak* drip board, grooved as shown, and a splash back (18 inches) high, with a molded cap, securing the splash board with *round-headed brass* screws. Provide also and set a ($1\frac{1}{2}$ -inch) *oak* frame for the kitchen sink and laundry wash trays. This frame shall be constructed solidly and secured properly. The covers for wash trays shall be constructed of ($1\frac{1}{4}$ -inch) straight-grained *oak*, the end cleats to be (3 inches) wide, rabbeted, and the body of the covers built up in pieces not exceeding (6 inches) in width. Hang the covers with *brass* hinges, secured with *brass* screws. The wash trays shall be supported on a strong frame of (2 in. $\times$ 4 in.) surfaced *white pine*, framed together; the legs to be of *pine* (4 inches) *turned* as indicated.

Woodwork in Cellar.—Furnish the storeroom in cellar with a *slat* platform built for barrels (4 inches) high, made of (2 in. $\times$ 2 in.) *Georgia pine*, the strips spaced (1 inch) apart and secured to (2 in. $\times$ 4 in.) cross-pieces laid flat. This platform shall be built in two sections. Erect *five* ($\frac{1}{4}$ -inch) shelves on *two* sides of the room, the lower shelf to be (3 feet 6 inches) above the floor, these shelves to be supported by (2 in. $\times$ 3 in.) *pine* standards placed at intervals of (4 feet). Construct a *slat* partition at the end of the storeroom to form a wine room; hang thereon a strong door made in like manner, attaching it with *heavy wrought-iron strap* hinges and providing it with a hasp secured with bolts and a *brass Yale* padlock with three keys. Put in the first shelf (3 feet 6 inches) above the floor and space the shelves above (9 inches) apart, the shelves to be of ($1\frac{1}{4}$ in. $\times$ 10 in.) surfaced *pine*. Place a ($\frac{3}{4}$ in. $\times$ 3 in.) strip along the front edge of each shelf with ($1\frac{1}{2}$ -inch) half rounds, sawed out (4 inches) on centers, to receive the necks of bottles. Support the shelves on (2 in. $\times$ 3 in.) *pine* standards.

Coal Bins.—Construct two coal bins with ($\frac{7}{8}$ in. $\times$ 9 $\frac{1}{2}$ in.) matched *North Carolina pine* boards, well nailed to the framing. Frame the bins with (2 in. $\times$ 4 in.) *hemlock* to run to the ceiling and spaced (30 inches) on centers; the corners to be formed with two (2 in. $\times$ 4 in.) pieces spiked together. The bins shall have doors hung with strong

wrought-iron strap hinges, and provided with hasp and lock. Form a grooved guide and place removable slides on the inside of door jambs.

Cellar Water Closet.—Build a raised platform and enclose the water closet with ($\frac{3}{8}$ in. $\times$ 4 in.) matched *pine*, beaded and surfaced on both sides, the partitions to run from floor to ceiling. Lay the floor of ($\frac{7}{8}$ in. $\times$ 6 in.) *spruce* of the same quality as that used for the under floor in the first story. Construct a door with *three* (6-inch) battens, put on with screws, the door to be hung with (3 in. $\times$ 3 in.) loose pin butts, and provided with a suitable lock. Finish around the partition at the ceiling with a neat bed molding.

Swing Shelves.—Construct and hang *two* swing shelves where indicated on plan, these shelves to be (2 ft. $\times$ 8 ft.) formed of (2-inch) surface plank and supported from the ceiling on *two* ($\frac{3}{8}$ in. $\times$ 1 $\frac{1}{2}$ in.) *wrought-iron straps*.

Sash Glazing.—The cellar and attic sash shall be glazed with clear, *double-thick American sheet* glass, well tacked and puttied. All sashes in first and second stories shall, unless otherwise specified, be glazed with best *clear French plate*, well bedded, tacked, and puttied, or set with stops, as required by the detail drawings. The sash marked, "stained or metallic set glass," shall be *boxed and sent for glazing* to the address obtained from the architect.

The owner shall select the designs and pay for the stained glass, as well as the cartage and expressage thereon to and from the glazier's. The contractor shall be responsible for its safety from breakage while the glass is in the building, until the last payment on the work shall have been made.

Door Glazing.—The upper part of the vestibule door shall be glazed with *clear French plate* glass, well bedded and set in with stops.

21. In order that the hardware manufacturer may readily determine the quality of goods required for each specified purpose, the section of the specification describing the hardware should be separated or kept apart from the other work, under a subheading.

HARDWARE.

All hardware shall be of (*The Yale & Towne Mfg. Co.'s*) manufacture, and shall all be furnished and placed in position by the contractor. The *vestibule, parlor, dining room*, and *library* shall have plain *Bower-Barff* finished hardware. All other hardware throughout

the building shall be, unless otherwise specified, of plain, *solid bronze*, secured with screws to match. The hardware in the cellar shall be of *iron, japanned*.

Door Hardware.—The front and vestibule doors shall have mortise locks, with plates, night latch, and keys, complete. The front door shall have a (3-inch) *mortise* bolt and a *bronze* push-button plate for bell. The vestibule door shall have *two* (3-inch) mortise bolts, top and bottom, one in each section; also one Dutch door bolt, between the sections, to match. All outside doors shall have *bronze* escutcheon plates. The kitchen and cellar outside doors shall have *steel* mortise locks with *bronze* fittings, and all other hardware to match. Provide a *combination* push button and speaking-tube mouthpiece plate of *bronze* at the kitchen door.

All sliding doors shall be hung with overhead *ball-bearing tubular* hangers, properly set with all fittings complete; the doors to be equipped with a sliding-door mortise lock; and with all fittings to match other hardware. The *double-acting* doors at the pantry shall have *double-acting check-spring* hinges, and plain *bronze* push and *kick* plates. All regular doors throughout the building, except the closet doors in the second story and attic, shall have mortise locks, with all furniture complete. All closet doors in the second story and attic shall have *rim* locks on the inside of doors, with furniture to match other doors. The pantry closet, cupboard, clothes closet, and wardrobe doors, shall have suitable locks, etc., while all drawers shall be provided with locks, buttons, and pulls to match other hardware.

Hinges.—Hang the front door with *three* ($4\frac{1}{2}$ in. $\times$ $4\frac{1}{2}$ in.) loose pin butts; the vestibule door with *two* (4 in. $\times$ 4 in.) loose pin butts to *each* section; all principal doors of ($1\frac{3}{4}$ inches) thickness, or over, with *two* (4 in. $\times$ 4 in.) loose pin butts. Provide loose pin butts for all ($1\frac{1}{2}$ -inch) doors ($3\frac{1}{2}$ in. $\times$ $3\frac{1}{2}$ in.), and for all other doors of the requisite sizes demanded. Hang all cupboard doors, wardrobe doors, etc. with butts to match other hardware; and provide and set all other butts or hinges required to finish the work as specified or indicated.

Bolts and Keys.—The front and vestibule doors shall be provided with bolts as hereinbefore specified. The kitchen outside door shall have a (4-inch) *mortise* bolt; the outside cellar door shall have a (4-inch) *wrought-iron-barrel* bolt. All outside doors shall have *three* keys; all other doors in the building *two* keys.

Sash Hardware.—All double-hung sashes shall have burglar-proof sash locks of an approved design; the lower sash to be provided with *two flush-plate* sash lifts, attached with *brass* screws. All double side-hinged sashes shall be hung with loose pin butts and be provided with top and bottom *combination spring* bolts, with a *lever* handle and

suitable lock. The single side-hinged sash shall be hung in like manner and provided with a *spring* sash lock having a *lever* handle. The single sash in the cellar shall be attached *on top* with two hinges, and be provided with a *spring* lock, and a suitable hook and staple. Provide and put in place all hardware required, including that in the kitchen, whether specifically mentioned herein or not, in a manner to finish the work fully, and to leave it in good order for use.

Door Stops.—All doors throughout the building shall, unless otherwise specified, have hard wood, turned door stops, with rubber nibs for walls and rubber cushion for floor stops. The door stops for front and vestibule doors, as well as those for halls, parlor, library, and dining room, shall be of *metal*, turned and finished to harmonize with other hardware, and provided with rubber nibs. The stops in those rooms having *bronze* hardware shall be *solid bronze*, turned.

Hooks.—Provide and set *bronze* clothes hooks in all closets, and wardrobe hooks in wardrobes and closets in the second story and attic, all spaced not more than (12 inches) apart. Also provide kitchen closet with suitable pot hooks as well as other hooks required.

Blind Hardware.—Hang all outside blinds with *wrought-iron* L hinges, made to throw the blind clear of the outside casing. Put on all fasteners and attachments required to leave the blinds in good working order.

22. Tinning and tinner's work are usually included in the plumbing contract, though when the amount of work in these trades is small, it is customary to include the flashing, etc. in the carpenter's contract, leaving to his discretion who shall perform the work.

The same may be said regarding the ironwork, though this is as often included in the mason's contract, especially where it includes only such details as gates, gratings, etc. If there is much ironwork, however, it should be specified in a separate contract.

TINNER'S WORK.

The tinner shall furnish flashings of *N. & G. Taylor's "old style"* tin, painted on both sides, as follows: (a) **Gutter flashings** to run (8 inches) under the shingles. (b) **Chimney flashings** to run (6 inches) under the shingles and well up on all sides of the chimneys. (c) **Apron flashings** to be cut on a line with, and (1 inch) from, the shingles; these to be furnished the mason and built in by him.

(d) **Dormer flashings** to run (6 inches) under the shingles, and up (8 inches) on the face and cheeks. (e) **Hip and ridge flashings** to extend (7 inches) on each side. (f) **Valley flashings** to extend (10 inches) on each side.

Put up flashings also over all window caps or other wood projections, running the tin (6 inches) under the clapboards or other outside finish, dressing down the edges and nailing securely. The flashing on the belt-course cap shall not extend under the plaster finish. The tinner shall lay all the flashings, except the apron flashing on chimneys, when notified by the carpenter to do so. Fasten all well, with tinned wire nails, making a neat and water-tight job. All tin shall be well locked together, having the joints soldered with half-tin-half-lead solder, using resin as the flux. All resin shall be cleaned off before paint is applied.

Gutters.—Line the gutters, as formed by the carpenters, with tin, as herein specified, neatly dressing it down, leaving no sags, turning the edges over moldings, and tacking down smoothly. Form tubes at the outlets, flare on top and solder well to the gutter. The paint used for tin shall be composed of the best metallic paint, ground in pure linseed oil. (See specifications under "Painting," Art. 27.)

Leaders.—Furnish and place in position, at the proper time, *nine corrugated galvanized-iron* leaders, at the points indicated on the drawings. The principal leaders shall be ($3\frac{1}{2}$ in. $\times$ $4\frac{1}{8}$ in.); those for veranda, etc. to be ($2\frac{1}{8}$ in. $\times$ $2\frac{3}{4}$ in.), all having the necessary offsets, and the principal leaders provided with square, molded leader heads, as indicated. Cover the openings to the leaders with *galvanized-iron* wire baskets, and secure the leaders to the building by means of *ornamental galvanized wrought-iron straps*, secured with *brass round-headed* screws; the straps to be spaced not more than (6 feet) apart. The lower end of the leaders shall be crimped and fitted to the drain pipe, using cement to make the joint tight.

IRONWORK.

Provide and set wrought-iron gates and fittings complete, as required by the detail drawings. Provide and set, at the proper time, all area gratings, window guards, coal-chute covers and frame, etc., to conform to drawings. All anchors, hinge and catch hangers for *ironwork* in ashlar or other limestone, shall be of *bronze*, leaded in. The owner shall provide, and the plumber shall fit up in good working order, a wrought-iron lamp at the porte cochère.

23. Under the general heading of "Plumbing" should be included all the work and material pertaining to the

plumbing work in the building. Sometimes the heading is extended to include gas-fitting, as both these trades are usually practised by the same mechanics.

As the lines of pipes and the location of traps are not usually shown on the general drawings, it is necessary to describe in detail all the work to be done by the plumber, in order that he may prepare his estimate intelligently.

PLUMBING.

All excavation and filling-in required for the plumbing work shall be done by the mason. The carpenter shall do all necessary cutting of timbers or other woodwork, but the plumber must notify each when such excavation, filling-in, or cutting is required; and no timber shall be cut unless absolutely necessary. With reference to all work not covered by the specifications and drawings, the plumber shall be governed by the rules and regulations as to plumbing and drainage established by the local authorities.

The plumber shall furnish all materials and perform all requisite labor for the execution and completion in a workmanlike manner of all plumbing in accordance with the plans and specifications. All materials shall be of the best, free from defects of any kind. The mason shall close all pipe openings in walls and ceilings, and the carpenter shall close all pipe openings in the floors, after the pipes are set in position and tested.

Cast-Iron Pipe.—All cast-iron pipes and fittings shall be sound, smooth on the inside, cylindrical, free from cracks or sand holes, of uniform thickness, and of average weight per foot in (5-foot) lengths, as follows:

Diameter.	Weight per Foot.
2 inches.....	5½ pounds.
3 inches.....	9½ pounds.
4 inches.....	13 pounds.
5 inches.....	17 pounds.
6 inches.....	20 pounds.

All branch connections in the cast-iron pipe shall be made with Y branches and obtuse-angle bends, except as otherwise specifically mentioned and defined. All cast-iron pipes shall be coated with *asphalt* outside and inside, after they have been tested at the foundry.

Joints in Cast-Iron Pipe.—All joints in the cast-iron pipes shall be made with picked oakum and molten lead, calking the joints well and bedding the oakum in the joints to a point (1½ inches) below

the top of the hub. Run in the molten lead, filling the joint, and calk the lead firmly in place with hammer and calking iron. Each joint shall have at least *twelve* ounces of lead to each inch of the pipe's diameter. No putty or cement joints of any kind shall be permitted.

Lead Pipe.—All branch lead, soil, waste, and vent pipes and all lead bends shall be of the best quality and of the following weight per lineal foot:

Diameter.	Weight per Foot.
1½ inches.....	3 lb. 8 oz.
2 inches.....	4 pounds.
3 inches.....	6 pounds.
4 inches.....	8 pounds.

All connections between lead and iron pipes shall be made with heavy brass ferrules, having an inside diameter slightly larger than the outside diameter of the lead pipe: to be set in the hub of the iron pipe and calked with picked oakum and molten lead; the lead pipe to be attached to the ferrule with a good wiped solder joint. All connections between lead pipes shall be made by wiped solder joints.

Tests.—The foreman plumber, or person in charge of the plumbing work, shall stop up all outlets and inlets in the iron and lead pipes comprising the vent and drainage system, including all branches and connections, in the presence of the architect and the inspector of the local building or health department. Test the system, then, by filling the lines with *water*. Should any bad leaks occur in the joints, necessitating the emptying of the pipes, they shall be refilled, and, after the leaks have been stopped, again tested. Any lengths of pipe or fittings showing cracks or sand holes should be removed, and a new length of pipe or fitting inserted, without the use of short lengths of pipe, collars, or double hubs.

Earthen House Sewer.—The plumber shall lay the house sewer from the outside of the foundation wall to a point (5 feet) or more from the cesspool, of salt-glazed, vitrified earthen pipe, cylindrical and straight, and not less than ($\frac{3}{4}$ inch) in thickness. The sewer shall be run with a uniform grade of not less than ($\frac{1}{4}$ inch) to the foot; the trench to be leveled evenly its entire length, and the pipes thoroughly laid and bedded so that no sags can occur. All joints to be made with *hydraulic Portland* cement as specified for other drains. The ends of each length of pipe shall be wetted before laying. Pack the earth well on each side of the pipe, taking care, however, not to crack any of the joints.

Main Drain Trap.—The plumber shall set a (4-inch) cast-iron running trap at the point indicated in the trap pit, having a handhole, with a brass ferrule and screw cap calked into each hub. Calk on the outlet end of trap sufficient cast-iron pipe to run at least 5 feet outside the foundation wall, and connect there with the earthen sewer pipe.

Fresh-Air Inlet.—Put in a fresh-air inlet of *cast-iron* pipe (4 inches) in diameter from the inlet side of the main drain trap to the point indicated on the drainage plan, and extend the pipe upwards (10 inches) above grade, finishing with a suitable *cast-iron* cap.

House Drain.—Put in the house drain from the main drain trap, along the cellar wall as shown, running at a uniform grade of ($\frac{1}{4}$ inch) to the foot. Continue the line beyond the inlet for risers, as shown, and finish with a brass ferrule and screw-cap.

Area Drains.—Provide and set in position a (6 in. $\times$ 6 in.) cast-iron *bell* trap and strainer for each window area and the cellar entrance area, the mason setting it properly in position and working the concrete around it. The window area drain shall be connected to the leader drain by (3-inch) salt-glazed vitrified pipe; the pipe to be connected to the bell trap and laid so that the joints shall run in the direction of the flow. All connections shall be made with Y branches and bends, and the joints cemented together. The cellar entrance area shall discharge into a dry cesspool, as specified under "Masonry."

Soil Pipe.—Place a cast-iron soil line, connecting with the house drain by a Y branch and bends, and extending full caliber to a point (3 feet) above the roof. The soil line shall have (4-inch) Y branches for water closets, and (2-inch) Y branches for other fixtures. Connect with the above described Y branches, (4-inch) *lead bends* for water closets and short lengths of (2-inch) *lead pipe* for other fixtures, except where otherwise specified or where running lines of waste pipe occur, in which case the fixtures shall be attached to the soil line, through lengths of (2-inch) *cast-iron* pipe where not exposed to view.

Waste Pipes.—Fit up the main waste line, as shown, of (3-inch) cast-iron pipe for the kitchen, laundry, and pantry fixtures; connect with the house drain and extend at least (3 feet) above the roof; put in a (3 in. $\times$ 4 in.) increasing fitting inside the roof line, and extend above with a length of (4-inch) cast-iron pipe. The waste pipe shall have (2-inch) Y branches on each floor, and each of the fixtures on this line shall be connected with short lengths of (2-inch) *lead* pipe, as shown, unless otherwise specified.

Vent Pipes.—Fit up (2-inch) *galvanized wrought-iron* vent lines with (2-inch) branches for water closets, and ($1\frac{1}{2}$ -inch) branches for other fixtures, as indicated on the plans. Connect by short lengths of *galvanized wrought-iron* pipe and *nickel-plated brass* pipe where exposed, (2 inches) in diameter, with the crown of each water-closet trap, except the vent pipe in the cellar, which shall be connected to the closet with (2-inch) *lead* pipe and brass solder nipple. Put in for all other fixtures ($1\frac{1}{2}$ -inch) *galvanized wrought-iron* branches, with *nickel-plated brass* where exposed to view. Extend the main vent line up to the

roof, increasing it to (4 inches) in diameter and carrying it up at least (3 feet) above the roof. The vent line for the waste-pipe stack shall be connected to the waste stack at a point above the highest fixture. The vent lines shall be connected to the soil or house drain below the lowest or last fixture on the line, with a bend and Y-branch connection.

Arrangement of System.—The pipe lines throughout the building shall be so arranged and placed in order to be as direct as possible, avoiding all offsets or unnecessary bends, all to be graded so as to discharge freely; and all horizontal lines of waste and vent pipes to be given a good grade towards the outlet. The joints between the pipe lines and the roof shall be made tight with a (6-pound) sheet-lead flashing turned into the pipe hub and dressed down smoothly all around; the joint to be calked in the same manner as other joints in the cast-iron pipe throughout the building; each pipe extending above the roof shall have a globe wire-basket strainer at the opening.

Leaders.—The tinnerns shall furnish and fit up all leaders and connect them with the drains.

Safes.—Provide and set (1½-inch) *countersunk Italian marble slabs* under the water closet, bath tub, and lavatory in the *principal* bathroom, and under the water closet, bath tub, and *slop* sink in the *servants'* bathroom. Provide each safe with a flush *nickel-plated* strainer over the outlet. Place under the water closet in the cellar a safe of (6-pound) *sheet lead*, dressed down to the frame set by the carpenter. This safe shall *not* be drained.

Safe and Refrigerator Waste.—Connect all safes with (1½-inch) **D lead** branches, to discharge into a main safe waste of (1½-inch) *galvanized wrought iron*. This line shall discharge openly over and into the cellar sink. The joints between the *lead* and *iron* safe wastes shall be made with brass soldering nipples, threaded for iron and connected with a wiped solder joint to the *lead* pipe. The refrigerator waste shall be of (1½-inch) *galvanized wrought iron* and shall discharge separately into cellar sink, a safe waste trap being located near the refrigerator. The special refrigerator trap, which traps the cold air, must discharge openly into said safe waste trap.

Traps.—Trap all fixtures in the building in the manner shown on the plumbing plans—all to be accessible and as near the fixtures as possible. The traps shall be of the diameter and materials as follows:

(a) For water closets, (4-inch) trap and bowl combined. (b) For bath tubs, (2-inch) *lead, under floor*. (c) For lavatory, (1½-inch) *nickel-plated brass, above floor*. (d) For wash trays, (2-inch) *brass* (no plating). (e) For *butler's* sink, (8-inch) *brass, chilling grease trap, screw top*. (f) For kitchen sink, (8-inch) *brass, chilling grease trap, screw top*. (g) For cellar sink, (2-inch) *lead*. (h) For *slop* sink, (2-inch) *brass, nickel plated*.

All traps, except those for the *butler's* and kitchen sinks, shall be of the same weight and diameter as the branches to which they are attached. The connection between the water-closet traps and *lead-bend* outlets shall be made with a heavy brass floor flange, set in *red lead* and bolted down tight. The vent connections with the water closets shall be made perfectly gas-tight by means of *red lead* and properly faced flanges.

Cisterns.—The plumber shall provide and set on *nickel-plated* brackets over the water closet in bathrooms, a cistern (10 in. $\times$ 12 in. $\times$ 18 in.) in size, lined with (16 ounces) *planished copper*. The cistern in the *principal* bathroom shall be cased by the carpenter in *quartered oak* to harmonize with the trim of the room. The cisterns for *servants'* bathroom and *cellar* closet shall be selected by the architect from manufacturers' catalogue. The brackets shall be fastened to a board, which will be set by the carpenter. The plumber shall connect the bathroom cisterns with ($\frac{1}{2}$ -inch) supply and ($1\frac{1}{4}$ -inch) flush pipes of *nickel-plated brass*; the flush pipe to discharge into the closet bowl. The cistern in the *cellar* shall be supplied through ($\frac{1}{2}$ -inch) A A *lead pipe*, the flush pipe to be ($1\frac{1}{4}$ -inch) D *lead*, discharging into the closet bowl. Provide a suitable *nickel-plated* chain and pull for each closet cistern.

Furnish and fit up over the *slop* sink, at proper height for a good flush, a (6-gallon, 16-ounce) *copper-lined oak* cistern, supported on *nickel-plated brass* brackets and provided with (1-inch) *nickel-plated brass* flush pipe, *nickel-plated* chain, and *oak* pull complete.

Fixtures.—Furnish and fit up complete, in good working order, the following fixtures, hereinafter described:

(a) Water closets: One in *principal* bathroom; one in *servants'* bathroom; one in *cellar*.

(b) Bath tubs: One in *principal* bathroom; one in *servants'* bathroom.

(c) Lavatory: One in *principal* bathroom.

(d) Slop sink: One in *servants'* bathroom.

(e) Sinks: One in *butler's* pantry; one in kitchen; one in *cellar*.

(f) Wash trays: A set of *three* in *laundry*.

(g) Boiler: One in kitchen.

(h) Refrigerator: One in pantry (to be furnished by the owner).

(i) Kitchen range and laundry stove shall be furnished and set by owner.

24. Here should follow, under a subheading, a complete and detailed description of every fixture required in the building, giving, where possible, the manufacturer's name and the catalogue number, if such can be obtained.

DESCRIPTION OF FIXTURES.

Water Closets.—Provide and set in the principal bathroom an all-porcelain siphon-jet water closet of the best quality, American make, with flushing rim, complete, finished plain white, embossed; to be approved by the architect. This closet shall be provided with a *quartered-oak* seat and cover, both secured *to the bowl*; all fittings to be of *brass, nickel plated*. The closet, with seat, cover, cistern, supply and flush pipes, and pull, complete, together with *countersunk Italian marble safe slab*, to cost (\$87.00, net).

Set up in the *servants'* bathroom an all-porcelain front-outlet, wash-out, flushing-rim closet, provided with *oak* seat and cover secured *to the bowl*. All fittings shall be of *brass, nickel plated*. This closet, complete, with *countersunk marble safe slab*, cistern, etc., to cost (\$50.00, net).

Set up in the cellar an all-earthenware, front-outlet, washout, flushing-rim closet, provided with *oak* seat, cover, and back. All fittings on the seat and cover shall be of *brass*, the flush and supply pipes to be of *lead*, supported by hard metal tacks soldered to pipe and secured to board with screws. This closet, with cistern and all fittings complete, to cost (\$30.00, net).

Bath Tubs.—Provide and fit up in the *principal* bathroom a *porcelain roll-rim Roman* bath (5 feet 6 inches) long, decorated outside in *Delft* design with all necessary *nickel-plated brass* supply and waste fittings above the floor, having a *nickel-plated standing waste*, shut-off valves and floor flanges, complete, and *china* handles on waste and supply valves. The bath shall be supported on *glazed porcelain* legs.

Set up a *nickel-plated brass* combination *needle, shampoo, and shower*, the *shower* to be (8½ inches) in diameter and provided with a *thermometer* and *safety mixing chamber*; also a *white rubber curtain* and attachments, complete; provide and set up a neat *nickel-plated brass* sponge holder, *china* soap cup with *nickel-plated* holder, and a combination towel shelf and rack (26 inches) long; the bath and appurtenances complete, with *countersunk Italian marble floor slab*, to cost (\$350.00, net).

Provide and set in the *servants'* bathroom a *porcelain-lined iron roll-rim* plain bath (5 feet 6 inches) long, supported on *enameled-iron* legs, having a *nickel-plated brass standing waste*, and (¾-inch) *brass, nickel-plated* hot and cold supply pipes to floor. Provide, also, and set up a *nickel-plated* sponge holder, *china* soap cup with *nickel-plated* holder, and a *nickel-plated three-bar* swinging towel rack. This bath with *countersunk Italian marble floor slab*, complete, to cost (\$110.00, net).

Lavatory.—Provide and fit up a lavatory with *Italian marble countersunk slab* (33 in. × 24 in. × 1½ in.), a (16-inch) *back* and (5-inch)

aprons, *nickel-plated brass* legs and apron brackets, *oval* basin (19 in. $\times$ 15 in.) *ivory-tinted, nickel-plated combination* supply valves, with *china* handles, *nickel-plated* hot and cold supply, and waste pipes to the floor, with floor slab, complete, to cost (\$75.00, net).

Slop Sink.—Provide and set up a *porcelain-lined cast-iron flushing roll-rim slop* sink (24 in. $\times$ 20 in. $\times$ 12 in.) in size, with *combination trap, standard, (3-inch) nickel-plated brass* plug and strainer; having, also, a *nickel-plated* hot and cold combination *lever-handle* faucet and *nickel-plated* supply and flush pipes.

Kitchen Sink.—Provide and fit up in the kitchen a *porcelain roll-rim* sink (42 in. $\times$ 24 in. $\times$ 7 in.) with a (2-inch) *brass* coupling, strainer, and (2-inch) waste. This sink to have a *brass chilling grease* trap (8 inches) in diameter, with a $1\frac{1}{2}$ -inch *brass* vent, the sink to be supported on *polished brass legs*, and supplied with hot and cold water through finished brass faucets, with *lever* handles.

Pantry Sink.—Provide and fit up, on framework erected by the carpenter, a *porcelain pantry* sink (24 in. $\times$ 17 in. $\times$ 6 in.) in size, with *brass nickel-plated* strainer and rubber plug, with chain; having, also, a (2-inch) *brass* waste and (8-inch) *brass chilling grease* trap with ($1\frac{1}{2}$ -inch) *brass* vent. This sink shall be supplied with hot and cold water through a *nickel-plated compression combination goose-neck pantry faucet*, with a *china name plate* on each valve.

Sink in Cellar.—Provide and fit up in the cellar a *galvanized cast-iron* sink (28 in. $\times$ 20 in. $\times$ 6 in.) in size, with overflow and *brass* strainer. This sink shall be supported on *galvanized-iron legs* and have a (2-inch) *lead* waste and S trap and a ($1\frac{1}{2}$ -inch) *lead* back-air pipe. It shall be supplied with cold water only, through a ($\frac{3}{4}$ -inch) *galvanized-iron* pipe and ($\frac{5}{8}$ -inch) *brass* compression bib.

Wash Trays.—Provide and set up in laundry a set of three *porcelain enameled earthen* wash trays, each (30 in. $\times$ 25 in. $\times$ 14 in.) in size, supported on a strong wooden frame and *turned* wooden legs, set by the carpenter, who shall also furnish and set a *hard-wood* frame and covers, as hereinbefore specified. The wash trays shall have brass plugs, with chain, and brass strainers; waste through a (2-inch) *brass* pipe and trap, with a ($1\frac{1}{2}$ -inch) *brass* back-air pipe, all *nickel plated on the rough*; supply with hot and cold water through a ($\frac{3}{4}$ -inch) *galvanized-iron* pipe, and ($\frac{5}{8}$ -inch) finished brass faucets, with *lever* handles.

Boiler.—Provide and place in the kitchen a (60-gallon) *seamless copper* boiler, tested to withstand a pressure of (150 pounds), reinforced on the inside, and having a heavy *copper* dome. This boiler shall be connected with the waterback of the range by a (1-inch) *seamless*

drawn *brass* pipe, with *brass* couplings and bends, complete. Put in a ($\frac{3}{4}$ -inch) sediment pipe of *brass*, with round way stop-cock under the boiler; continue with a ($\frac{3}{4}$ -inch) *galvanized-iron* pipe, to discharge into *cellar sink*.

Refrigerator.—The owner shall furnish, and the plumber shall set, where shown, a refrigerator, and discharge its waste pipe over *cellar sink*, as specified.

Water Supply.—The entire premises will be supplied with water from the local water-works system. The main runs (6 feet) below the street on which the building fronts. The distance between the street main and the front cellar wall is (75 feet); the average depth required for the house service pipe is (5 feet 6 inches); the soil is assumed to be about 50% *hard pan* and 50% *loam*. The mason shall excavate and refill the trench for the water service pipe, and a tapper duly authorized by the local authorities shall, at the plumber's order, tap the street main, placing a ($\frac{3}{4}$ -inch) corporation cock at or near the point indicated, or as directed by the architect. The plumber shall lay on a solid bottom, and with a uniform grade down to the cellar, a (1-inch) A A A *lead* pipe, extending through the cellar wall. This pipe is to be protected externally with tarred felt where it passes through the wall, and a (1-inch) round-way extra heavy stop-cock, extension key rod, and cast-iron extension curb box of approved make, to be located at the curb; on the cellar end of this (1-inch) lead pipe wipe a brass solder nipple, and connect this to a ($1\frac{1}{4}$ -inch) lever-handle round-way stop and waste cock, with a ($1\frac{1}{4}$ in. $\times$ 1 in. $\times$ $1\frac{1}{4}$ in.) reducing T and plug between. From this stop and waste cock run a ($1\frac{1}{4}$ -inch) line of *galvanized-iron* pipe along the cellar ceiling until the first riser is reached; here it will terminate with a ($1\frac{1}{4}$ in. $\times$ 1 in. $\times$ 1 in.) reducing T. On the house side of the stop and waste cock, take off a branch and continue it with a ($\frac{3}{4}$ -inch) *galvanized-iron* pipe to supply a ($\frac{3}{4}$ -inch) garden-hose bib under the veranda, where shown on the elevation; place a ($\frac{3}{4}$ -inch) stop and waste cock in the cellar, clear from frost; grade this pipe back from the hose bib to the stop and waste cock.

From the ($1\frac{1}{4}$ -inch) reducing T aforesaid, run a (1-inch) branch to supply a ($\frac{3}{4}$ -inch) rising line to the bathrooms, and a ($\frac{3}{4}$ -inch) branch for laundry tubs. At the base of the riser, place a ($\frac{3}{4}$ -inch) stop and waste cock, and on the laundry tubs branch, place another ($\frac{3}{4}$ -inch) stop and waste cock. Run a ($\frac{3}{4}$ -inch) *galvanized-iron* riser up to the bathrooms, leaving off the necessary branches to supply cold water for each fixture; finish the top of the riser with an air chamber (6 feet) long. All exposed parts of this riser and its branches to be of *brass* pipe, *nickel plated*, and all wall and floor intersections to be covered with *nickel-plated brass* escutcheon plates.

From the ($1\frac{1}{4}$ -inch) reducing T aforesaid, run a (1-inch) *galvanized-*

iron pipe directly to the boiler and connect full size to its cold-water inlet tapping with a (1-inch) lever-handle stop and waste cock, close to the boiler. From this pipe run a ($\frac{3}{4}$ -inch) branch to the kitchen and cellar sinks. Connect the boiler to the range with (1-inch) *brass* pipe and ground unions. From the top of the boiler run a (1-inch) *galvanized-iron* hot-water distributing pipe up to the *principal* bathroom, leaving off branches for the several fixtures. Then reduce and continue up with ($\frac{3}{4}$ -inch) pipe to *servants'* bathroom, leaving off branches here; from the highest point return directly back to the boiler with a ($\frac{1}{2}$ -inch) *galvanized-iron* pipe; connect this to the bottom of the boiler. Place a (1-inch) stop-cock on the hot-water pipe from the boiler, and place a ($\frac{1}{2}$ -inch) stop-cock on the circulation pipe. From a point on the (1-inch) hot-water pipe, and between the top of the boiler and the stop-cock, take off a ($\frac{3}{4}$ -inch) branch to supply hot water for kitchen sink and laundry tubs; place a ($\frac{3}{4}$ -inch) stop and waste cock on this branch. Air chamber the pipe on the top of the boiler with air chambers (3 feet) long; arrange the stop-cocks in a neat and symmetrical manner; all pipes in the kitchen to be exposed and screwed on the face of pipe boards to be furnished and put in by the carpenter. The branches to the fixtures shall be as follows:

For baths, ($\frac{3}{4}$ -inch).

For water-closet cisterns, ($\frac{1}{2}$ -inch).

For lavatory, ($\frac{1}{2}$ -inch).

For all sinks and wash trays, ($\frac{3}{4}$ -inch).

Pipe Supports.—All pipes running under the cellar ceiling shall be supported therefrom; cast-iron pipe, by strong wrought-iron *adjustable* hangers; water supply and other pipes, by solid metal straps. All pipes running along the cellar walls, and all standing lines, shall be supported by heavy *galvanized wrought-iron* hooks, (5 feet) apart. Pipes running between the floor joists shall be uniformly supported on suitable shelves, to be furnished and put in by the carpenter, under the plumber's direction.

All exposed supply pipes in the kitchen, laundry, and pantry shall be supported neatly and equidistant, by tinned straps, secured by *round-headed* screws to the pipe boards. The plumber shall grade each supply pipe line so that when the water is shut off, the line shall be completely drained; each rising line to be provided with a stop-cock so that any one may be controlled independently of the other.

After the plumbing system is finished and the traps all sealed with water, an approved smoke test must be applied for the architect's satisfaction. This final test must be made satisfactory, also, to the local inspector of plumbing. The plumber shall obtain the permit for and turn on the water. He must go over the work and see that every joint and connection on the premises is perfectly tight and the system in good working order.

25. As said before, the gas-fitting is usually included in the plumber's contract, but to facilitate his work it should be separated under a subheading. However, if the gas-fitting is separated from the plumber's work entirely, it should be described under a general heading, as in the other trades.

GAS-FITTING.

Gas-Fitting.—The entire premises shall be supplied with gas from the local gas works, the tap to be made on the main under the street on which the building faces. The service pipe, from the street main to the inside of the front property line, shall be put in by the local gas-light company, which shall, also, at the proper time, place the meter in position, making connection with it on the inlet side. The gas-fitter shall lay a (1½-inch) *galvanized* wrought-iron main, covered outside with asphalt paint, from the front property line to the inside of the cellar wall, and up to the point at which the meter shall be placed. He shall attach a heavy brass stop-cock to the main, inside the cellar wall. He shall, likewise, continue the main of (1½-inch) and the risers of (¾-inch) wrought-iron pipe. All branches shall be taken from the side or top of the running lines. All running lines shall be free from sags or traps, and all graded towards the meter at the front cellar wall. There shall be, in all, 96 gas outlets. All side lights in the first-story rooms and halls shall be (5 feet 9 inches) above the floor, and all other lights (5 feet) above the floor. All nipples for drop lights shall be set perfectly plumb, and centered in the rooms. In putting up drop-light nipples, screw on a long piece of pipe and plumb it, after which the pipe may be removed. All nipples for side lights shall project (1½ inches) from the studs for plastered walls, and shall be set perpendicularly to the walls. All side lights shall be supplied through a (¾-inch) pipe; the drop lights in the dining room through a (½-inch), and all the other drop lights through a (¾-inch) pipe.

Place in due position a (¾-inch) pipe for the *gas* range in kitchen, making all connections thereto. All pipe ends shall be reamed, and the joints shall be screwed up with red lead, the outlets capped up, and the system proven tight by the *mercury* test. No split pipe, nor damaged or inferior material of any kind, will be accepted or allowed. The gas fixtures shall be furnished and put up by the owner.

26. Heating is usually the subject of a separate contract, though sometimes it is included in the plumber's work. In either case it should be separated under a distinct heading and every detail carefully described.

HEATING.

The building will be heated with a *hot-air* furnace, by the natural-draft system. The heating contractor shall furnish the best of materials and workmanship to execute his work in a substantial manner, according to the drawings and this specification. The work shall conform to the laws and regulations of the local building department, or civic ordinances, and also to the rules of the fire underwriters.

The carpenter shall do all cutting of timbers required, and the owner shall furnish the necessary fuel to test the efficiency of the plant.

The contractor shall give all necessary measurements or information required by the mason, to enable the latter to build the furnace pit, brick furnace enclosure, cold-air duct, and to set iron door frames.

Furnace.—Provide and set up in the cellar, where shown, a *cast-iron* furnace, having a sufficient grate area and heating surface to furnish sufficient heat to properly warm the several rooms, with an ordinary amount of attention, during *zero* weather. The furnace shall be brick-set by the mason, and provided with the necessary clean-out doors, etc., which the heating contractor shall furnish to the mason, who will set them in place under the furnaceman's supervision.

The heating contractor shall work in harmony with the mason, and be responsible for the latter's work in connection with the furnace. There shall be provided for the furnace a wrought-iron hoe, poker, grate shaker, steel shovel, and evaporating pan, complete.

Smoke Pipe.—Connect the furnace with the smoke flue in the chimney, by means of a (No. 20 gauge) *galvanized-iron* smoke pipe, having a well fitted *lever* damper, with a **T** joint and a cold-air *check* damper.

Cold-Air Duct.—Provide and set in position, as shown on the cellar plan, a vertical cold-air duct, of proper dimensions, connecting at the foundation wall with the brick cold-air duct. This cold-air duct shall be made of (No. 20 gauge) *galvanized* iron and have a ($1\frac{1}{2}$ in. $\times$ $1\frac{1}{2}$ in. $\times$ $\frac{1}{4}$ in.) *angle-iron* flange at the floor and against the wood frame in the wall opening. Insert a suitable *pivoted* damper and cover the wood frame on the outside with a *galvanized-iron* wire screen having a ($\frac{1}{4}$ -inch) mesh.

Heater Pipes.—Run the cellar pipes and vertical stacks to the various registers as shown on the plans, each to have a damper placed near the furnace. The pipes in the cellar and the stacks from the cellar to the first-floor registers should be round; those for the second story, running through partitions, should be flat. All stacks and pipes running through partitions shall be double, with a ($\frac{1}{2}$ -inch) air space between. All woodwork in partitions or in the neighborhood of heater pipes shall

be covered with IX bright tin, having lapped joints, turned around on the sides of the studs or other woodwork and well nailed thereto. The tin used for this purpose shall not be soldered. All plastered partitions over heater pipes shall be covered with *expanded metal lath*.

Pipe Covering.—Cover all pipes in the cellar with *two* layers of *sheet asbestos*, weighing not less than (10 pounds per 100 square feet), and paint on each pipe, in neat letters, with black paint, the name of the room to which it runs.

Registers.—All registers shall have suitable frames and IX *tin* boxes, and shall be well set, flush with the floor or the wall. The registers and frames in the floor shall be *black japanned*, and those in the walls, except parlor registers, shall be *bronzed*. The parlor registers shall be finished in *white porcelain enamel*.

Guarantee.—The contractor shall submit to the owner a written guarantee that the heating apparatus shall heat the rooms in the building as shown in the drawings to a temperature of (70°) F. in *zero* weather. In case, however, that *zero* weather may not occur within *one year* after the completion of the work, the contractor will be required to prove by scientific data that the system is capable of accomplishing the above requirements. Should any part of the system fail to fulfil the terms of this covenant, or any part prove defective within the time limit of the guarantee, he shall remedy all failure and defect, at his own expense, leaving the plant in good working order at the completion of the repairs.

27. Under the subject of “Painting” should be included all the work pertaining to the surface finish of the exterior and interior of the building, whether confined to plain painting or inclusive of finishing, varnishing, and polishing of the hard-wood finish.

Glazing is sometimes included under this heading, though equally often it is included in the carpenter’s work, especially when the glazing refers to sashes, etc., which are to be supplied by the carpenter.

PAINTING.

The painter shall provide his own scaffolding, ladders, and utensils, providing all materials of the best description, and the skilled labor required to perform his work in an acceptable and workmanlike manner.

Painted Work in General.—Cover all sap, knots, or other defects in the woodwork about to be painted, with a good coat of *shellac* before painting. See that all nails are set in, and after applying the priming coat, putty up all nail holes or cracks.

Exterior.—Paint all exterior woodwork, unless otherwise specified, including fences, clothes posts, etc., with *three* coats of paint composed of the best *American* white lead and pure linseed oil. The building shall be trimmed in *three* colors selected by the owner. Paint all exposed tin work, leaders, etc., on the building with *three* coats of *metallic* paint, ground in pure *boiled* linseed oil.

Shingle Staining.—All shingles to be placed on roofs or dormers shall be *dipped two-thirds* of their length in *creosote shingle* stain, of a tint approved by the architect or owner. The shingles shall then be stacked up and allowed to dry before being put on.

Treatment of Ironwork.—Paint all ironwork in the cellar, the *wrought-iron entrance* and *carriage* gates, and all other ironwork on the premises with a priming coat of pure *red oxide of lead* and *boiled* linseed oil. Finish with *two* coats of *white lead* and linseed oil paint, of such colors as may be approved.

Interior.—The *parlor* woodwork, including the *mantel* and the *picture* molding, shall be painted *white*, with *three* coats of pure *white lead* and linseed oil paint, each coat to be sandpapered before the next is applied. Finish with a coat of paint composed of *French zinc white* and *spirits of turpentine*. *Size* and *gild* the *pearl* and *bead* molding, etc., as directed.

All rooms in the second story and attic, except the second-story hall, shall be painted *three* coats of *white lead* and *linseed oil paint*, in *white* or *light tints* as approved by the owner. The *last* coat shall have a little *copal* varnish added and be *rubbed down* to a smooth, even surface.

All woodwork in the cellar shall be painted *two* coats of such colors as may be approved.

Natural Wood Finish.—All *hard wood* in the principal rooms, including the first and second story hall, stairs and mantels, shall be sandpapered smooth, removing all finger or other marks, and given a coat of mineral wood filler, which shall evenly fill the grain of the wood, and be wiped off while *wet*. Finish with *one* coat of pure *white shellac* and *two* coats of best *body varnish*. *Rub* between *each* coat, and *rub down* the last coat with pumice stone and *water*. Clean out all quirks of the moldings before applying the varnish.

The treads and risers of the stairs shall be *filled* and given *two* coats of the best *body varnish* *rubbed down* after *each* coat with pumice stone and *water*; and shall be finished with a coat of *oil* and *wiped*

off well. The *rear stairs* shall be finished in like manner. Finish all other woodwork in the first story, including the inside woodwork of *book cases* in the *library* and all closets in the building, with a coat of filler and *two* coats of *body varnish*. The *last* coat in *exposed places* shall be *rubbed* to a smooth, even surface. The tops of drip boards at sinks shall have a coat of filler and one of oil.

Floor Finish.—The floors of all principal rooms in the first story and the floors of hall and principal bedrooms in the second story shall be given a coat of mineral wood filler, a coat of *hard oil* finish, and a coat of best *floor wax*. *Sandpaper* after the *hard oil* has been applied, and rub the *floor wax* in well with special *weighted brushes*. Care must be taken that the floors be smooth and that paint or other spots be removed before applying the filler.

The remainder of the first and second story floors and the attic floor shall be filled and finished with a good coat of *hard oil*.

Wall Treatment.—The walls of all rooms and halls in the first story and *principal* bathroom shall receive a coat of *shellac* size and *three* coats of *paint*. The first *two* coats of *paint* shall be composed of pure *white lead* and linseed oil, the second to be *stippled*. Finish the walls with a coat of *zinc white*, ground in *spirits of turpentine*, tinted as approved by the owner and *stippled*. All rooms shall be finished in *two* tints.

Finish of Wood Ceilings.—Give the veranda, porte-cochère, and porch ceilings a coat of mineral wood filler, rubbed in well, and finish with *two* coats of best *spar varnish*.

28. Under "Electrical Work" is usually included not only the wiring of the premises for electric lighting, but, also, the running of wires for electric bells and other means of communication between different parts of the house. Speaking tubes are also sometimes included under this head when their number is too small to warrant a special contract.

ELECTRICAL WORK.

All the electrical work herein included shall be executed according to the rules and regulations adopted by the National Board of Fire Underwriters, and subject to the inspection and approval of the local Board of Fire Underwriters. The contractor shall pay all charges for the inspection of the work, and, upon its completion, secure a satisfactory certificate of its acceptance. He shall also furnish guarantees pledging himself to maintain, at his own expense, the very best service.

and secure, likewise, at his own charge, for a period of *two* years, the efficiency of the system, and shall submit both to the architect.

System.—The building shall be thoroughly equipped, from the source of supply to each outlet, with *brass armored* insulated conduits, put up in such a manner as to provide continuous insulating channels for all wires, and the tubes to be so well connected as to exclude water and gas.

To the end that each and every wire may be at all times accessible for inspection or repairs, the location, junctions, elbows, position of switches, etc., and the final emergence of the tube beyond the surface at the fixture, must be effected, executed, and placed in accordance with the rules herein set forth, and the manner indicated on the drawings.

The sizes of the wires shall be determined on the basis of each lamp requiring (50) volts and (1) ampere. There shall be *one* group of risers for the building, the wiring on each floor to run from *one central point*, taking in all outlets. All tubes shall be of sufficient size to allow the wires to be readily drawn in or replaced at will; no tubes less than ($\frac{5}{16}$ inch) inside diameter shall be used; all tubes to be secured in place with metal clips, and no staples allowed unless absolutely necessary.

Where a number of elbows is unavoidable, an intersection box must be put in to facilitate the work of drawing in or replacing the wires. All tubes must emerge at outlets, in terminal boxes, leaving the outlets protected from plaster, etc. Place in position junction boxes from which all branches shall run, and use *standard* cut-outs; the boxes shall be formed by the carpenter, provided with hinged doors and lined with sheet asbestos. Protect each branch wire with a safety fuse.

All conduits and wires shall be concealed under the plastering or other finish. Blow *powdered soapstone* into the conduits, that the wires may be the more readily drawn in. All the principal rooms shall be wired in such a manner that the lighting may be controlled by a switch, located on the *side wall*, or elsewhere, as may be directed. All *hall*, *vestibule*, and *veranda* lights shall be controlled by *one* switch, placed at the *rear* of the *main* hall.

Place the most approved knife switch and cut-out box on the service wire at its entrance to the cellar. Insert a properly insulated tube in the wall for the reception of the main; this tube shall be graded to the inside of the building. A loop shall be left for the meter inside of the main switch. All annunciators or bell wires shall be placed within conduits and be readily accessible.

Bells.—Provide and set *two nickel-plated gong* bells, one for the *front door* and one for the *kitchen outside door*. The bells, connected with the electric system of the house, shall be placed in the *kitchen*, and left in good working order. The *carpenter* shall provide and set the push-button plates.

Annunciators.—Provide and place in the *kitchen* a neat annunciator box, made of *quartered oak*, the front hinged, and glazed with clear *plate* glass. This box shall have a ($2\frac{1}{2}$ -inch) *nickel-plated gong* bell, and metal drops for each of the principal rooms in the first and second story. Extend wires from the annunciator box to the various rooms. Provide and set in place in each room a metal plate and push button to correspond with the hardware of the room.

Speaking Tubes.—Furnish and erect, with mouthpiece and whistle complete, (1-inch) tin speaking tubes from the *kitchen door*, *dining room*, *second-story hall*, the *owner's bedroom*, *principal bath-room*, and *cellar*, to the *kitchen*. The pipes shall be well fitted together and run as direct as possible.

All work throughout the premises shall be executed in a practical, skilful, and satisfactory manner, and every precaution taken to preserve the most complete insulation and secure the preservation of all tubing from moisture or injury. Everything must be left in good order for use.

A SERIES
OF
QUESTIONS AND EXAMPLES
RELATING TO THE SUBJECTS
TREATED OF IN THIS VOLUME.

It will be noticed that the Examination Questions contained in the following pages are divided into sections corresponding to the sections of the text of the preceding pages, so that each section has a headline which is the same as the headline of the section to which the questions refer. No attempt should be made to answer any questions or to work any examples until the corresponding part of the text has been carefully studied.

CARPENTRY.

(ARTS. 1-284 SEC. 9.)

EXAMINATION QUESTIONS.

(1) How should the first course of shingles be laid on the roof?

(2) When is it necessary to truss a partition?

(3) What is the essential difference between the method of flashing hips and the method of flashing valleys?

(4) (a) What is meant by a *single* floor? (b) What is meant by a *double* floor? (c) How is each laid?

(5) (a) What is a water-table? (b) For what purpose is it intended?

(6) What woods are best suited to the rough framing of a house?

(7) How may dry rot be prevented in wood columns?

(8) (a) Into how many divisions are trees classified according to their methods of growth? (b) What are they called? (c) Which furnishes the best wood for building purposes?

(9) (a) How should the boards of a veranda floor be laid? (b) How are the joints rendered water-tight?

(10) When is it necessary to truss door or window openings?

(11) Why is especial care required in laying the roof at the eaves?

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(12) What is matched flooring?

(13) Describe the method of determining the curve to which the edges of beveled siding must be worked in order to properly fit the surface of a circular tower.

(14) What woods are best suited for damp situations not in contact with the earth?

(15) In slow-burning construction, how are the floor-beams tied together throughout the building?

(16) What are the inner layers of the heart wood of a tree called?

(17) How are the valley rafters treated in a gable roof which intersects with a main roof of greater height?

(18) What are dormer-windows?

(19) (a) How far apart are partition studs usually placed?
(b) Why?

(20) What is a chamfer?

(21) Why are splines used in plank floors?

(22) What woods are best suited to situations in contact with damp soil?

(23) What are medullary rays?

(24) (a) What is a gable roof? (b) What is a gambrel roof?

(25) (a) What are wood centers? (b) How are they constructed?

(26) How is the sill of a house laid on the foundation wall?

(27) On what should the feet of studs rest (a) when the partition runs across the beams? (b) when it runs parallel with the beams?

(28) (a) What is a trimmer-arch center? (b) How does it differ from an ordinary center?

(29) What wood is well suited to a dry, well ventilated position?

(30) (a) What is a hip roof? (b) What is a Mansard roof?

(31) What wood and what sizes of plank are best suited to floors in slow-burning construction?

(32) What are the best seasons to cut trees for lumber?

(33) What are spherical pendentives?

(34) What is the thickness of a mortise in proportion to the timber in which it is cut?

(35) Why is it necessary to have the same thickness of sill under all partitions and walls of the same house?

(36) How are lath secured in the angles of a room?

(37) (a) What is a dome? (b) How is it framed in wood?
(c) How is it covered?

(38) (a) What is Carolina pine? (b) Is it as durable as Georgia pine?

(39) How are partitions formed in slow-burning construction?

(40) At what age do trees arrive at their maturity?

(41) What is a groined ceiling?

(42) In braced-frame construction, how are the interties framed with the corner posts, when the floorbeams are parallel with the front of the building?

(43) Why is sheathing usually laid diagonally?

(44) How are the second-story beams carried in balloon-frame buildings?

(45) For what purpose was slow-burning construction first introduced?

(46) (a) What wood makes the best piles? (b) Why?

(47) What is the difference between braced-frame construction and balloon-frame construction?

(48) In slow-burning construction, how are the beam ends protected when they rest in a brick or stone wall?

(49) What are cup shakes?

(50) What is quarter-sawed timber?

(51) (a) How is the steel square used to mark the cuts of rafters? (b) Explain the use of the fence as applied to the steel square.

(52) What two methods are used in spacing the studding of exterior walls?

(53) (a) Is hemlock a good material for first-class framing? (b) Why?

(54) What is a fish joint?

(55) What are fungi?

(56) Why are shingle lath preferable to close boards as a roof covering under shingles?

(57) How should lumber be piled in order to season properly?

(58) Why should the ends of beams be cut on a slant when they rest in a brick wall?

(59) What is the simplest joint between two pieces of wood?

(60) What is a mortise joint? (Describe in detail.)

(61) What is the characteristic difference between slow-burning construction and ordinary wood construction?

(62) How are the tops of floorbeams maintained at a uniform level in a building?

(63) Why is it necessary to set jack-rafters in pairs, one each side of the hip or valley?

(64) (a) What do the figured dimensions of doors and windows represent on architects' plans? (b) What must these dimensions be in the rough frame openings?

(65) (a) What is flashing? (b) When is it used?

(66) (a) What are brick nogs? (b) When are they used in a frame building?

(67) What are plaster grounds?

(68) What is the general system employed in slow-burning construction?

(69) What wood is best adapted to tanks and other vessels constantly filled with water?

(70) In slow-burning construction, why are iron beams sheathed with wood?

(71) (a) What are heart shakes? (b) What causes them?

(72) What is a liberal proportion of leader to roof area?

(73) (a) What is the difference between beveled siding and novelty, or patent, siding? (b) Which is the better?

(74) What are furring strips?

(75) What is the ultimate object of the system of slow-burning construction?

(76) What are the best woods for shingles?

(77) What are (a) headers? (b) trimmers? (c) tail-beams? (d) How are they joined together?

(78) What is rot in timber?

(79) How are walls lathed and plastered in slow-burning construction?

(80) (a) What are purlins? (b) How are they cut to miter?

JOINERY.

(ARTS. 1-116. SEC. 10.)

EXAMINATION QUESTIONS.

(1) What method is generally adopted where several stiles and rails of a door are to be veneered at one time ?

(2) Describe in detail the method of veneering a small cylinder.

(3) In bending wood by saw kerfing, how may the proper spacing of the saw kerfs be determined ?

(4) Show the method of obtaining the length and shape of the soffit of a semicircular window in a straight wall, the jambs of which splay equally all around from the center line at an angle of 30° . The wall is 2 feet thick, and the window 3 feet wide on the inside; scale, $\frac{1}{2}$ inch = 1 foot.

(5) A semicircular-headed window in a curved wall is 4 feet 6 inches wide, and the wall is curved with a radius of 8 feet. Show the method of developing the window head, the wall being 2 feet thick with a 4-inch reveal, and the jambs of the window parallel. Scale, $\frac{1}{2}$ inch = 1 foot.

(6) How are the moldings on sash bars treated where they intersect ?

(7) How is the parting strip of a window frame held in place ?

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(7) How may the widths of the stiles and panels of a wainscot be determined, when the number of the panels and the length of the room are known?

(8) What are *bases* or *skirtings*?

(9) What is the effect of shrinkage in mitered joints?

(10) Describe the process of joining two thin veneers.

(11) How should the cores of veneered doors be prepared?

(12) (a) What five methods are used to bend wood?
(b) Which is considered the best?

(13) (a) Make a full-size diagram showing the method of obtaining the bevel for an octagonal pyramid whose base is 1 inch on each side and the perpendicular height to the apex is 4 inches. (b) Show how the bevel should be held to test the angles.

(14) How should the weights of the upper and lower sashes be proportioned?

(15) What are French windows?

(16) How is the amount of bevel determined, necessary to enable a folding door to open and close readily?

(17) (a) What are *architraves*? (b) How are their upper edges joined?

(18) In a pantry (a) about what should be the height of the service table? (b) about what should be the depth of the dresser?

(19) (a) What is a *caul*? (b) How is it prepared for use?

(20) In dovetailing a hopper of the dimensions given in question 28, in what direction should the dovetail pins be cut?

(21) How may the sash cord be secured to the sash?

(22) What quantity is a box of window glass assumed to contain?

(23) How are the pockets for sliding doors framed?

(24) What method is adopted to prevent broad, plain surfaces from warping?

(25) Describe the common dovetailed joint.

(26) In hanging doors, what details must be taken into consideration to determine the proper projection of the hinges?

(27) For what reason are hard-wood veneers generally used?

(28) Make a diagram showing the method of obtaining the miter cut for a square hopper which is built of material 6 inches thick, 4 ft. $\times$ 4 ft. on top, 2 ft. $\times$ 2 ft. on the bottom, inside measurements, and 2 feet deep. Scale, $\frac{1}{2}$ inch = 1 foot.

(29) Describe the operation of hanging the sash in a window frame after it has been fitted.

(30) What consideration generally determines the dimensions of window sashes?

(31) Describe a device for securing the stiles and rails of a door, other than the mortise and tenon.

(32) What is the best method of securing a long, plain, unpaneled wainscot against warping or shrinking?

(33) State the distinction between carpentry and joinery.

(34) Where is the half-lap dovetail joint frequently used?

(35) What are *veneers*?

(36) Show the method of obtaining the length and shape of the soffit of a semicircular window in a concave wall, the jambs of which splay out at an angle of 30° with the center line of the opening, and the soffit of which, at the top of the opening, is level. The wall is 1 foot 6 inches thick,

the opening 3 feet wide on the inside, and the radius of the curvature of the wall 7 feet to the outside line. Scale, $\frac{1}{2}$ inch = 1 foot.

(37) What is *splayed* work in joinery?

(38) How are the mortise-and-tenon joints secured in a sash?

(39) How is a water-tight joint secured between the stone sill and the wooden sill of a window?

(40) What is a *dado*?

(41) (a) What is the characteristic difference between the joints made use of in carpentry and those used in joinery?

(b) Into what two general classes are these latter joints divided?

(42) For what reason is the blind-dovetail joint used?

(43) How are inside blinds hinged to insure their unobstructed closing into the blind box?

(44) It is required to bend a pine plank around a cylinder whose diameter is 15 feet. What thickness of plank may be used without steaming or other preparation?

(45) Show the method of obtaining the length and shape of the soffit of a semicircular window in a curved wall, the jambs of which window radiate from the center from which the curve of the wall is struck. The wall is 2 feet thick, the opening 4 feet wide on the inside, and the radius of curvature of the wall 6 feet to the inside. Scale, $\frac{1}{2}$ inch = 1 foot.

(46) (a) Show the method of preparing a face mold for the top rail of the sash to be inserted in the window frame described in question 5. (b) How should this face mold be applied?

(47) How are the meeting rails of a sash made?

(48) What is a *mullion*?

(49) What are *relishes* in framed work?

(50) (a) Why is a chair rail used in an apartment?
(b) How high should it be placed?

(51) (a) What process is necessary to secure a first-class job of gluing? (b) How can the quality of glue be tested?

(52) Describe the method of mitering a straight molding and a circular molding when the two intersect at an acute angle.

(53) Show by sketch the details of a cornice for a store front.

STAIR BUILDING.

EXAMINATION QUESTIONS.

(1) (a) State a method of altering the stairway shown in Fig. 21. (b) Show how to lay out an easement curve for a stringer.

(2) (a) Define riser, tread, and step. (b) What is meant by flight and by landing?

(3) (a) What are balusters? (b) When are they fixed to the tread, and when to the stringer? (c) How many balusters are generally set on each tread?

(4) (a) What are curtail steps and bull-nose steps? (b) How are right-hand and left-hand stairways distinguished from each other?

(5) (a) What is a cylinder in a stairway? (b) What is a fascia?

(6) (a) What advantage is possessed by the form of construction shown in Fig. 44? (b) What by that shown in Fig. 47?

(7) (a) How is the housing of a stringer made? (b) How are the steps supported between the stringers if the stairway is wide?

(8) (a) How should the finished work on a stairway be protected during the construction of the building? (b) To what are creaking noises in the stairway due?

(9) (a) How are the treads and risers attached to each other? (b) Describe the method of forming a bull-nose step.

(10) What are fliers and winders?

(11) (a) Why is the number of treads in each flight one less than the number of risers? (b) A riser has a height of 7 inches; determine the width of the tread by rules I and II.

(12) Make a sketch showing a method of describing the curves of a curtail step.

(13) What is the proper height for a riser in order to insure easy stepping?

(14) Describe two methods of arranging the treads in an elliptical stairway.

(15) How should moldings be worked?

(16) Given a tread of 9 inches, determine the height of the riser by rule III.

(17) What are the advantages of arranging the risers as shown in Fig. 40?

(18) (a) How are portions of hallways adjoining the stairway sometimes finished? (b) Describe a method of fastening wainscoting so that no nails will be seen on the face.

(19) (a) What is meant by an *open* stringer? (b) What is a *close* stringer?

(20) How are platforms supported in frame and brick walls?

(21) (a) What are the common lengths of pin balusters? (b) When two balusters are placed on one tread, how should they be arranged?

(22) (a) To what depth are the risers and treads usually housed? (b) In geometrical stairways, how are the rails supported?

(23) Describe a method of scribing a wall stringer.

(24) (a) What is a pitch board, and what care should be exercised in making it? (b) Show by sketch the usual method of housing the risers and treads in a stringer.

(25) (a) What is a newel? (b) Where are starting and angle newels usually placed?

(26) Name the materials of which stairways are constructed, and state when each should be used.

(27) (a) What should be the least headroom for a stairway? (b) What arrangement is followed when there are winders at the bottom of the flight?

(28) (a) What is an open-newel stairway? (b) When is a stringer said to be wreathed?

(29) Make sketch of and describe the construction of a common factory stairway.

(30) What distance should exist between the center line of the rail of the flight and the fascia of the landing?

(31) Show how to find the length of arc of a semicircular cylinder, following the method shown in (d), Fig. 23.

(32) (a) What is a dog-leg stairway? (b) What objection is there to its use?

(33) (a) Name the principal points to be considered in designing a stairway. (b) Give the minimum widths of stairways in public and private buildings.

(34) (a) Mention some points to be considered in setting the hand rail. (b) What is a ramped hand rail, and what is its object? (c) When a continued hand rail is used, how may it be braced or stiffened?

(35) Show by sketch and explanation how to obtain the hand-rail easement shown in Fig. 30.

ESTIMATING AND CALCULATING QUANTITIES.

(ARTS. 1-75. SEC. 19.)

EXAMINATION QUESTIONS.

(1) (a) State the number of pounds and kind of nails required for laying 1,000 shingles, 1,000 square feet of beveled siding, and 1,000 square feet $1\frac{1}{8}$ -inch finished flooring.

(b) State the length and number per pound of 4d., 10d., and 20d. common nails.

(2) (a) How many square feet of roof will a box of $14" \times 20"$ tin cover, if laid with flat lock-seams? (b) About how much does tin roofing cost per square foot?

(3) (a) Using regular coursed bluestone ashlar, what will be its cost per square foot, laid in the wall, including cost of dressed stone, hauling, and setting? (b) What is the cost per square foot of 3-inch flagstone for a 4-foot walk, including cost of setting?

(4) (a) About how many square yards of wood and brick will 1 pound of paint cover, first and second coats? (b) About how many square feet will 1 gallon of shingle stain cover if the shingles are rough-sawed?

(5) (a) What items does the estimate for "Carpentry" include? (b) Using either of the rules for board measure, how many board feet are there in a $3" \times 8"$ piece, $18\frac{1}{2}$ feet long?

Ans. (b) 37 ft. B. M.

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(6) Mention some of the points to be considered in estimating on the water-supply system.

(7) Analyze the cost of 1 square yard of a concrete cellar floor.

(8) State the approximate cost of heating by hot air, by steam, and by hot water, expressed as percentages of the cost of the building.

(9) Analyze the cost of 1 square of slating.

(10) (a) At about what per cent. of the cost of the building may the cost of the gas-fitting be estimated? (b) What proportion of the cost of materials will be the cost of labor?

(11) Analyze the cost of 1,000 feet B. M. of hemlock framing.

(12) State the proportions of materials and amount of labor necessary to lay 1 perch of rubble masonry, using 1-to-3 lime mortar.

(13) What are the materials generally used for roof covering?

(14) (a) Show how to find the exposed length of a shingle. (b) Explain the method of finding the number of shingles required per square.

(15) Show how the cost of finished floor per square foot may be determined.

(16) (a) How is excavation measured? (b) Mention some points requiring consideration in fixing the price of excavation.

(17) (a) In estimating brickwork by the cubic yard, how many bricks should be figured? (b) In computing footings, how many bricks, per lineal foot, should be allowed for an 18-inch wall?

(18) Give the analysis of cost of 100 square yards of 3-coat plastering.

(19) (a) State how many square feet of granite, blue-stone, and sandstone a stone cutter can cut in a day. (b) About how much should be allowed for waste in dressing stone?

(20) (a) State the method of figuring wooden cornices. (b) For general carpentry work, what per cent. of the cost of materials is the cost of labor?

(21) (a) Name some of the reasons why a successful estimator should have an extensive experience. (b) In making an estimate, what points should be kept in view?

(22) (a) About what will be the cost per step of an ordinary 3-foot stairway? (b) What part of this cost will be for material, and what for labor?

(23) (a) About what per cent. of the cost of the building may be used as the approximate estimate for hardware? (b) About what per cent. of the cost of hardware will be the cost of labor of fitting, etc.?

(24) (a) How many square feet will 1,000 shingles, 6 inches wide and exposed 5 inches, lay? (b) How many, of the same size and exposure, will be required for 100 square feet of roofing?

(25) (a) What is the general proportion between the cost of labor and that of materials, in painting? (b) What in varnishing?

(26) State the approximate cost of both window frame and sash, per window of two lights, each 28 inches square.

(27) (a) In making an estimate, into what three general subdivisions may the work be divided? (b) State the order in which the separate branches of work should be taken up.

(28) (a) How is molded work figured? (b) At what price may paneling be estimated?

(29) (a) What is meant by an approximate estimate? (b) Make an approximate estimate of cost of a small house 18 ft. $\times$ 28 ft. $\times$ 18 ft. high to eaves, with 7-foot cellar, and

half-pitch roof, assuming the cost to be 8 cents per cubic foot. Ans. \$1,189.44.

(30) (a) How many pieces of $8'' \times 12''$, and of $12'' \times 20'$ slate will be required per square? (b) About how much does slating cost per square foot?

(31) Give a general rule for estimating the number of studs (a) when set at 16-inch centers; (b) when set at 12-inch centers.

(32) (a) How should glass be measured? (b) What is single and double thick glass? (c) How many $12'' \times 18''$ panes does a box contain?

(33) (a) State the approximate cost of both frame and door for a $2' 8'' \times 6' 8''$ opening. (b) About how many ordinary doors can a man hang and trim in a day?

(34) (a) Show how to find the number of rolls of paper required for a room. (b) About how much does paper hanging cost per roll?

(35) (a) What are the general sizes and thicknesses of sawed shingles? (b) About how many shingles can a man lay per day on straight work?

(36) (a) How is wainscoting measured? (b) How are stairways usually figured?

(37) Give the analysis of cost of 1 square foot of ashlar.

(38) (a) At what per cent. of cost of building may the cost of plumbing be approximately estimated? (b) What proportion of the cost of plumbing materials will be the cost of labor?

(39) Two men in a 9-hour day can put in place about how many feet of (a) studding? (b) matched sheathing, laid diagonally? (c) siding?

(40) (a) At what figure may bridging be estimated? (b) How may the number of board feet of sheathing, laid diagonally, be found?

(41) (a) Give the quantities of oil and drier required per 100 pounds of lead for the first, second, and third coats of paint. (b) For what reason is drier usually omitted in all coats after the first?

(42) (a) About how many square yards of 3-coat plastering can be laid in a day by two plasterers and one laborer? (b) About how much per square yard will the labor on 2-coat plastering cost, exclusive of lathing?

(43) (a) Name the two classes into which stone is separated at the stone quarry, and describe each. (b) How is ashlar figured?

(44) (a) How much must the actual area be increased if 6-inch siding is to be used? (b) How much for 4-inch stuff? (c) In what case is it not necessary to figure base and corner boards separately?

(45) (a) What will be the cost of an ordinary 5-foot veranda, including balustrade, with 2-inch turned balusters? (b) Where the veranda is partly curved, how may the cost of such portion be estimated?

(46) (a) State the amount of material and labor required to lay 1,000 bricks, using 1-to-3 Rosendale cement mortar. (b) What is the cost of common brickwork per 1,000 bricks, laid in a 1-to-3 lime mortar? (c) If the work is measured without deducting openings, what per cent. less than the figures for kiln count should be used?

(47) What will be the cost of 16 feet of $1\frac{1}{8}"$ ($1\frac{1}{4}"$) $\times$ 5" window jambs, according to the rule given for estimating molded work?

(48) Make a schedule of some of the items to be considered (a) in masonry; (b) in steam heating; (c) in gas-fitting.

(49) How is the exposed length of a slate determined?

(50) (a) What is the reason for increasing the actual area of the floor in computing finished flooring? (b) If $1\frac{1}{8}$ -inch floor is used, how much must the actual area be increased?

(51) (a) How is plastering usually measured? (b) What is the smallest opening that should be deducted in figuring plastering? (c) How are cornices measured?

(52) (a) How is brickwork usually estimated? (b) For each square foot of wall 3 bricks thick, how many bricks are allowed?

(53) (a) What is the most common error made in figuring roof areas? (b) Show how to find the length of a valley rafter.

(54) About what is the cost per thousand of putting on laths?

(55) What items are included in estimating joinery?

(56) (a) How is painting measured? (b) For what reason are balustrades, etc. counted solid?

SPECIFICATIONS.

(ARTS. 1-28. SEC. 23.)

EXAMINATION QUESTIONS.

- (1) What is a specification ?
- (2) For what purpose is it written ?
- (3) What relation does it bear to the drawings ?
- (4) What qualifications are necessary to enable one to write a clear, comprehensive specification ?
- (5) What points should be kept in mind in writing a specification, that it may be practical in every sense ?
- (6) Name the several general headings in a complete specification for an ordinary frame building.
- (7) In what order should the several headings be placed ?
- (8) What general principles should be kept in mind in writing a specification, that there may be no possibility of doubt as to the meaning implied in any part of it ?
- (9) Name two words the use of which should be avoided, unless their meaning is fully explained.
- (10) Stipulate in full the terms of the guarantee which should be set forth in the specification in regard to the requirements of the heating apparatus.
- (11) (a) Why is a general-condition clause required in every specification ? (b) Why is the wording of this clause of more importance than that of any other in the specification ?

For notice of copyright, see page immediately following the title page.

(12) (a) What part of the work is the general-condition clause intended to cover? (b) In what way does it cover the work?

(13) Name ten items that are usually stipulated in the specification regarding interior finish.

(14) What is meant by *débris and rubbish*?

(15) To what depth should the joints be raked out before pointing mortar is applied?

(16) Name two items that are usually omitted from the specifications and let under a separate contract.

(17) Name four tests employed for the purpose of detecting poor workmanship in plumbing pipe lines, or defects in the pipes and fittings.

(18) (a) In what connection is the word *provide* used in a specification? (b) When should the phrase *provided and set* be employed instead?

(19) In cold climates, why should the foundation walls be carried at least 4 feet below grade?

(20) How should the stone and brick wall surfaces in the cellar be treated before whitewash is applied?

(21) In what part of the work does the specification require that metal lath be used?

(22) Why does the specification require the finished floors to be covered with felt paper?

(23) How is the plumber governed in executing work not included in or covered by the drawings and specifications?

(24) What distinctive names are given in a specification to the rough framing of a building, and the finer, or finishing, work?

(25) What disposition is made of all excavated earth, rock, etc. not required for filling in and grading?

(26) (a) How are the joints between lengths of gas pipe treated? (b) How is the pipe system prepared for testing?

(27) What provision is made for cleaning out the chimney flues in the cellar?

(28) What test is applied to the plumbing system, prior to the final acceptance of the work?

(29) To whom is the stair work of a building usually entrusted?

(30) How many ounces of lead would be required in making a joint in a 5-inch cast-iron waste pipe?

(31) Under whose direction is the glazing of the window sashes, etc. usually done?

(32) How is the veranda lamp controlled?

(33) Against what destructive agents should the electric wires and tubes throughout the building be protected?

(34) Where is Vicat cement mortar used in the construction of the walls?

(35) What work should be done on the roofs before the carpenter places any shingles in position?

(36) In what contract would the tin speaking tubes and attachments be included?

(37) Where is a steel brush employed for the purpose of cleaning stonework?

(38) In the construction of window frames, (*a*) where is Georgia pine used? (*b*) Where is oak used?

(39) At what points on the building are galvanized-iron wire baskets placed?

(40) What contractor is required to lay the mosaic floor of the bathroom?

(41) Why should the plumbing lines and fixtures be fully described in a specification?

NOTE.—In writing the following specifications, it should be borne in mind that the examples given are merely to test the student's ability to construct the phrases in a manner to include all the work required, making them as brief as possible.

(42) Specify the work and materials, including the mortar, etc., required to excavate for, and build a stone pier of rubblework below grade and faced with ashlar above?

(43) Specify the work and materials required to build an ordinary flight of stairs.

(44) Specify the work and materials required to supply a building with water from the street main, to the inside of the cellar wall.

(45) Specify the laying of a finished hard-wood floor; also, the finishing of the same, exclusive of painter's work.

(46) Specify the laying of ordinary shingles on a pitched roof.

(47) Specify the painting of a veranda with three coats of paint, including floors and natural-finished ceiling.

(48) Give a short digest for a general-condition clause suitable for a cheap country dwelling, omitting unnecessary phrases.

A KEY
TO ALL THE
QUESTIONS AND EXAMPLES
INCLUDED IN THE
EXAMINATION QUESTIONS.

It will be noticed that the Keys have been given the same section numbers as occur on the headlines of Examination Questions to which they refer. All article references refer to the Instruction Paper bearing the same section number as the Key in which it occurs, unless the title of some other Instruction Paper is given in connection with the article number.

To be of the greatest benefit, the Keys should be used sparingly. They should be used much in the same manner as a pupil would go to a teacher for instruction with regard to answering some example he was unable to solve. If used in this manner, the Keys will be of great help and assistance to the student, and will be a source of encouragement to him in studying the various papers composing the Course.

CARPENTRY.

(QUESTIONS 1-80. SEC. 9.)

(1) The first course of shingles should be laid at the eaves and doubled. See Art. **157**.

(2) A partition should be trussed when there is no support for it from the story below, or when it is pierced by several doors or other openings, likely to render it insufficient to carry its superimposed load. See Art. **127**.

(3) Flashing on hips is applied in small pieces laid with each course of shingles, while flashing in the valleys of a roof is in the form of a continuous gutter left open between the slopes. See Arts. **162** and **163**.

(4) (a) A single floor consists of but one course, or layer, of boards nailed directly to the beams. See Art. **111**.

(b) A double floor consists of two courses of floor boards, the first being laid of rough material, and the second course, called the finished floor, being laid of better stock and blind nailed through the under floor to each beam.

(c) A single floor is always laid at right angles to the beams. A double floor is usually laid with its first or under course at an angle of about 45° with the beams, and its upper or finished floor at right angles to the beams. See Arts. **112** to **115**.

(5) (a) The water-table is a projecting strip around the lowest part of the woodwork of the building, on top of which the clapboards or siding finish.

(b) Its purpose is to receive the rain water that runs down the side of the house and throw it to the ground clear of the foundation wall. See Art. **188**.

(6) For first-class work, Georgia pine; for ordinary work, spruce; for cheap, rough framing, hemlock. See Arts. **42**, **43**, and **45**.

(7) By boring a hole lengthwise through the column to ventilate the interior.

(8) (a) Three.

(b) Exogenous, endogenous, and acrogenous.

(c) The exogenous trees. See Arts. **8** and **9**.

(9) (a) The boards should be laid across the veranda from the house line to the edge, and with a pitch of $\frac{1}{4}$ inch to the foot to drain the water off.

(b) The joints should be laid in white lead. See Arts. **192** and **193**.

(10) When they are more than three feet wide. See Art. **129**.

(11) Because in cold climates the heat in the house is likely to cause the snow on the roof to melt and run down to the eaves, where, relieved from the influence of the internal heat, it is likely to freeze and form a dam, or ledge, of ice, and the water will then back up under the shingles and leak into the house. See Art. **166**.

(12) Matched flooring consists of planks which have been planed to a uniform thickness, and whose edges have been tongued and grooved to make a tight joint. See Art. **111**.

(13) A line is drawn representing the vertical axis of the tower, and to any given scale a section of a piece of siding is drawn at a distance from this axial line equal to the

external radius of the tower. The intersection of the prolonged inside line of the section of siding with the axial line of the tower, will then give the center from which the curve may be drawn, and the distance from this center to the upper and lower edges of the section of siding will be the radius of the upper and lower curves, respectively. See Art. **190**.

(14) Cedar, cypress, and chestnut.

(15) By means of iron dogs, which are bars with turned-over ends laid across the girder so that the turned ends fit into and tie together two floorbeams abutting on opposite sides of the girder. See Art. **221**.

(16) Duramen. See Art. **11**.

(17) One of the valley rafters is carried to the ridge of the main roof just as though both gables were of the same height, and the other valley is framed to the first one at the height of the lower ridge. See Art. **149**.

(18) Small windows projecting from the roof of a building. See Art. **167**.

(19) (a) Sixteen inches.

(b) So that the 4-foot lengths of lath will extend over four studs and get a bearing on each one without cutting or extending beyond. See Art. **116**.

(20) A chamfer consists of the surface of a cut angle or corner on a timber where such corner has been removed for a portion of the length only, and the timber retains its original shape for some distance from each end. See Art. **196**.

(21) To make a tight joint and keep the tops of the adjacent planks flush. See Art. **221**.

(22) Red cedar, redwood, and locust.

(23) The lines, radiating from the center of the tree toward the bark, which are seen in cross-sections of several of the hard woods. See Art. **15**.

(24) (a) A gable roof is one where the pitch falls in both directions from the center of the building.

(b) A gambrel roof is one with a gable whose slopes are broken so that the portion finishing at the eaves is steeper than the portion starting from the ridge. See Arts. **133** and **140**.

(25) (a) Centers are wood templets or molds, over which the voussoirs, or tapered stones of an arch, are placed to hold them in position until the mortar has set.

(b) They are constructed usually of two face pieces of $1\frac{1}{4}$ -inch plank, which, after having been sawed to the proper curvature, are spaced the required distance apart and covered over with a number of transverse strips called *lagging*. See Arts. **189** to **201**.

(26) The sill is laid on the foundation one inch back from the outside edge of the wall, and is bedded in a layer of mortar which is pointed up after the sill is laid and leveled. See Art. **171**.

(27) (a) When a partition runs at right angles to the beams, the ends of the stud should stand on a sill laid across and spiked to the beams, unless there is a supporting partition immediately below, when the ends of the stud should stand on the cap of the supporting partition.

(b) When a partition runs parallel with the beams, it should stand on a beam framed in especially to receive it, or should rest on the cap of the partition below, if such a partition exists. See Arts. **117** and **120**.

(28) (a) A trimmer-arch center is one used over which to lay the bricks of a supporting arch for a fireplace hearth.

(b) It differs from the centers usually placed for templets for arched openings, as it is left in place even after the arch is complete and set, and the lath and plaster of the ceiling below are secured to it. See Art. **202**.

(29) Georgia pine.

(30) (a) A hip roof is one without gables where all four sides slope back at a uniform pitch from the eaves to an apex or ridge at the center.

(b) A Mansard roof is one where the sides pitch back in a broken slope, the portion at the eaves being nearly vertical, while the slope from the apex or ridge is nearly flat. See Arts. **135** and **141**.

(31) Georgia pine or spruce plank 3 inches thick and not more than 6 inches wide is best suited for the under floor in slow-burning construction, while $1\frac{1}{8}'' \times 4''$ maple or hard pine is suitable for the finished floor. See Arts. **218** and **221**.

(32) At the season when the sap has ceased to circulate, which in temperate climates is midsummer and midwinter, and in tropical climates, the dry season. See Art. **17**.

(33) A pendentive is the spherical triangle which brings the curved plan of a dome down to the angular corner or pier which supports it over the intersection of two passages. See Art. **213**.

(34) One-third. See Art. **76**.

(35) In order that the shrinkage may be equal and the settlement of the house uniform. See Art. **121**.

(36) When the angle of the room corresponds with an exterior angle of the building, the lath is secured against the corner stud for one wall, and against a nailing strip spiked to the corner stud for the other wall. When the angle of the room is against a straight exterior wall, the first stud of the interior partition is spiked to a 1-inch plank which is 2 inches wider than the stud and projects 1 inch beyond each side. The lath on the exterior wall are then secured to the projection of 1-inch plank and the lath on the interior wall are secured to the stud itself. See Arts. **118**, **119**, and **122**.

(37) (a) A dome is the term applied to the roof of a building which is carried up either wholly or in part, in the form of a hemisphere or semiellipsoid.

(b) A dome is framed with rafters sawed to the required

curve, and framed between two circular members, called the sill and the plate, the former of which is equal to the plan of the base of the dome, and the latter to the plan of the opening or eye at the top.

(c) A dome may be covered with horizontal courses of planking, sawed to the required curve, and secured to the rafters; or it may be enclosed with vertical strips of plank, which are worked to a curved taper from their widest part at the base of the dome, to a pointed edge at the center of the top. These are secured to curved purlins framed in between the rafters at sufficient intervals to preserve the outline of the dome. See Arts. **203** to **206**.

(38) (a) It is a wood of the evergreen class, often substituted for Georgia pine in inferior work.

(b) No. See Art. **42**.

(39) Of 2-inch tongued-and-grooved plank laid vertically from floor to ceiling, which may be plastered over with wire lath on one side or lined with $\frac{7}{8}$ " $\times$ 3" matched boards of oak or Georgia pine. See Art. **223**.

(40) From 50 to 100 years. See Art. **18**.

(41) A groined ceiling is one formed over the intersection of two arched divisions or passages in a building. See Art. **209**.

(42) The interties are mortised into the corner posts so that the ones which run parallel to the floorbeams have their tops level with the tops of the floorbeams, and the ones which run at right angles with the floorbeams have their tops level with the bottom of the floorbeams which rest on them. See Art. **78**.

(43) To brace the structure on which it is laid. See Art. **180**.

(44) On a ledger board or girth let into the studs at such a height that the beams may be notched over it and spiked to each stud. See Art. **174**.

(45) For the construction of mills and factories, to obviate the difficulties met in the prevention or quenching of fires, so prevalent in structures of the braced-frame or balloon-frame construction. See Arts. **217** and **218**.

(46) (a) Spruce.

(b) Because it preserves well under water and resists the action of parasitic crustacea longer than any other similar wood. See Art. **43**.

(47) In braced-frame construction, each piece of the framework is carefully fitted and fastened to every other piece it comes in contact with, thus rendering the whole skeleton stiff and secure in itself, while in balloon-frame construction, the timbers and scantlings are simply nailed together lightly to hold them in place until the sheathing is applied to brace the structure and make it secure. See Art. **72**.

(48) They are provided with an air space around the ends in the wall by keeping the brickwork half an inch away from the beam or by using the Goetz-Mitchell or other suitable wall anchor. See Art. **226**.

(49) They are the circular cracks seen in the end sections of timber due to the separation of the fibers, from exposure to violent wind storms while the timber was standing. See Art. **22**.

(50) It is timber obtained from logs which have first been sawed in quarters, and each quarter then sawed into planks or scantling, as nearly as possible at right angles to the annual rings. See Art. **36**.

(51) (a) The square is set upon the rafter in such a position that the rise in inches is shown on the tongue, and the run in inches is indicated on the blade, both being on the same edge of the rafter. The tongue then marks the angle of the plumb-cut and the blade shows the bevel of the foot-cut, while the distance between the points where the tongue

and blade each cross the edge of the rafter will be $\frac{1}{12}$ the length of the rafter.

(b) The use of the fence obviates the necessity of a bevel in laying out the rafter cuts, or risers and treads of a stair string, etc., as by clamping it across the square from the tongue to the blade, these two elements of the square may be readily placed in their exact positions to mark the desired cuts. See Arts. **153** and **154**.

(52) In one method the studs are spaced regularly every 16 inches throughout the building and the openings are then cut out and framed with extra pieces, while in another method the openings are framed first with a double stud at each side and the single studs are then framed in 16 inches apart between these openings. See Art. **179**.

(53) (a) No.

(b) Because it is very brittle, splits easily, is very likely to be shaky, and is not durable. See Art. **45**.

(54) A fish joint is one where the two pieces of scantling to be joined are butted together, end to end, and secured in place by means of a board spiked to each side of the timbers over the joint. See Art. **87**.

(55) Parasitic plants which derive their nutriment from some other plant or from cut timber, and thereby reduce its vitality. See Art. **27**.

(56) Because they give ventilation to the under side of the shingles and prevent the accumulation of moisture. See Art. **157**.

(57) It should be piled in high and dry locations, kept well up from the ground on staging, with narrow strips placed between the layers to permit a free circulation of air. See Arts. **28** and **37**.

(58) So that when it sags in the center from any cause, it will not disturb the brickwork in the wall above it, even if it falls out of the wall entirely. See Art. **226**.

(59) The butt joint. See Art. 75.

(60) A mortise joint is one where the two pieces of timber are joined together and maintained in position by means of a tenon or tongue, projecting from one piece into a mortise or socket, which is cut out of the other. The mortise is usually cut out of the center of the timber, and is equal in width to $\frac{1}{3}$ the width of the timber. The tenon is cut to fit the mortise exactly and is also in the center of the timber. When the two pieces are of different thicknesses, the joint is usually framed so as to bring one face of each timber flush with the other. See Art. 76.

(61) One consists of a large number of small timbers, such as studs, braces, beams, bridging, etc., and the other—the slow-burning system—consists of a small number of large timbers, such as columns and beams, without studs, braces, or bridging between. See Arts. 217 and 218.

(62) They are notched on their under sides, to fit over the sill or the girth, and any irregularity in depth is removed when the notch is cut so that all the beams are the same depth from the top to the bearing surface. See Art. 108.

(63) To make the thrust against each side of the rafter equal and thereby prevent it from bulging out of line. See Art. 181.

(64) (a) They represent the sizes of the finished openings.

(b) To these dimensions there must be added 5 inches in height and 7 inches in width for windows with weight boxes, or, if without weights, an allowance of 3 inches in width will be sufficient. In doors an allowance of 5 inches in width and 3 inches in height should be made. See Art. 130.

(65) (a) Flashing is a term given to all sheet-metal work used in connection with roof covering to insure a water-tight condition at joints and angles.

(b) It is required on hips and valleys, ridges and eaves, around scuttles, skylights, gables, flanks of dormer-windows, etc. See Art. 161.

(66) (a) Pieces of old bricks used for filling in partitions.

(b) When it is desired to close the passageway between the studs of the outside walls, to prevent drafts and the consequent rapid spread of flames. See Art. **184**.

(67) They are nailing strips equal to the plaster in thickness placed against the studs at various heights to receive the trim or other interior finish and also form a stop for the plaster. See Arts. **123** and **185**.

(68) The system of slow-burning construction provides a structure where the individual members, such as beams, girders, etc., are few in number, but so large in size that they would retain sufficient strength to carry the load imposed upon them even after they have been burned $\frac{1}{3}$ through. See Arts. **218** and **219**.

(69) White cedar. See Art. **46**.

(70) To insulate them from the heat which they would otherwise absorb and likely become so hot as to bend and throw the walls or columns out of plumb. See Art. **229**.

(71) (a) They are rifts or cracks which radiate from the center of the log.

(b) Caused by shrinkage of the timber incidental to loss of vitality. See Art. **31**.

(72) One square inch of leader section to 75 square feet of roof area. See Art. **160**.

(73) (a) Beveled siding consists of sawed and planed boards in commercial lengths of about 16 feet and widths of from 4 inches to 6 inches, while the thickness is $\frac{5}{8}$ inch at the lower edge and bevels back to $\frac{3}{8}$ inch at the upper edge. Novelty siding has a uniform thickness of about $\frac{7}{8}$ inch, except where it is rabbeted at the bottom to receive the chamfered edge of the next board below it, and where it is chamfered to fit the rabbet of the next board above it.

(b) Beveled siding is the better. See Art. **187**.

(74) Furring strips are small pieces of timber, 1 in. $\times$ 2 in. in section, which are nailed to the under side of floorbeams to bring them to an even alinement. Furring strips are also used to isolate the plastering from the surface of a wall, thus forming an air space. See Art. 126.

(75) To make a building strong enough to stand any ordinary stress even after its timbers are partly burned; to make the floor sufficiently water-tight that when a fire gets started in one story the water poured in to quench it will not run through and ruin goods on the floor below; to avoid any corners or pockets where fire could get started without being immediately discovered; and, above all, to provide a building where every part is easily accessible and the fire could be attacked at close quarters, and extinguished, without flooding the entire structure. See Art. 219.

(76) Cypress and white cedar. See Arts. 46 and 48.

(77) (a) The short beam framed into and supported by two trimmer beams.

(b) Two heavy beams spaced one each side of a floor opening to receive the header on which the tail-beams rest.

(c) Those beams in a floor system, one or both of whose ends rest upon a header which transmits their loads to other beams, called trimmers, which are made especially heavy to support them.

(d) With mortise-and-tenon joints or occasionally with stirrup irons. See Arts. 79, 80, and 110.

(78) The disintegration of the fibers, due to the attack of parasitic plants. See Art. 27.

(79) Over stiffened wire lath laid directly against the woodwork of the partition. See Art. 232.

(80) (a) They are small roof beams, used when the main roof is supported by trusses, or heavy and widely spaced rafters, in order to provide members to which the roofing may be secured.

(b) Draw a plan of the purlin in its actual position on the roof and intersect the end of it with a diagonal line at the angle of the hip or valley rafter. From the first point of intersection of this valley-rafter line, draw a line across the plan of the purlin at right angles to its sides, and measure the distance from this last line to the points where the valley rafter intersects the corners of the purlin. Now, if these last distances are laid off successively on three adjacent corners of the purlin itself, and the latter is sawed to a line connecting them, the cut will be the miter required. See **Art. 150.**

JOINERY.

(QUESTIONS 1-53. SEC. 10.)

- (1) See Art. **93.**
- (2) See Art. **96.**
- (3) See Art. **86.**
- (4) See Art. **76.**
- (5) See Art. **65.**
- (6) See Art. **47.**
- (7) See Arts. **31** and **32**
- (8) See Art. **25.**
- (9) See Art. **7.**
- (10) See Art. **95.**
- (11) See Art. **93.**
- (12) (*a*) See Art. **85.**
- (12) (*b*) The method of bending and gluing together several layers. See Art. **89.**
- (13) See Art. **75.**
- (14) See Art. **62.**
- (15) Those hinged at the sides, hung in pairs, and closing in the center. See Art. **63.**
- (16) See Art. **44.**

- (17) (a) See Art. **22**.
(b) See Art. **24**.
- (18) See Arts. **110** and **111**.
- (19) See Art. **92**.
- (20) See Art. **72**.
- (21) See Art. **62**.
- (22) 50 square feet. See Art. **53**.
- (23) See Art. **43**.
- (24) See Art. **18**.
- (25) See Art. **12**.
- (26) See Art. **105**.
- (27) See Art. **91**.
- (28) The method to be employed is similar to that described in Arts. **71** and **72**.
- (29) See Art. **62**.
- (30) See Art. **53**.
- (31) See Art. **42**.
- (32) See Art. **28**.
- (33) See Art. **1**.
- (34) For the fronts of drawers. See Art. **13**.
- (35) See Art. **91**.
- (36) The method is clearly outlined in Art. **81**.
- (37) See Art. **70**.
- (38) See Art. **60**.
- (39) See Art. **52**.
- (40) See Art. **26**.
- (41) See Art. **2**.
- (42) See Art. **14**.
- (43) See Art. **99**.

(44) By the rule given in Art. **90**, the thickness is $.05 \times$ radius of curvature of bend. In this case the radius is $15 \times \frac{1}{2} = 7\frac{1}{2}$ feet. Hence, thickness $= 7\frac{1}{2} \times .05 = .375$ in. $= \frac{3}{8}$ in. Ans.

(45) The method is shown in Art. **78**.

(46) See Art. **66**.

(47) See Art. **57**.

(48) See Art. **51**.

(49) See Art. **36**.

(50) See Art. **26**.

(51) See Art. **5**.

(52) See Art. **84**.

(53) See Art. **114**.

STAIR BUILDING.

(QUESTIONS 1-35. SEC. 11.)

- (1) (a) See Art. 26.
(b) See Art. 28.
- (2) (a) and (b) See Art. 3.
- (3) (a), (b), and (c) See Art. 19.
- (4) (a) and (b) See Art. 3.
- (5) (a) and (b) See Art. 15.
- (6) (a) See Art. 48.
(b) See Art. 51.
- (7) (a) and (b) See Art. 9.
- (8) (a) and (b) See Art. 17.
- (9) (a) See Art. 11.
(b) See Art. 12.
- (10) See Art. 3.
- (11) (a) See Art. 7.

(b) By rule I, the width of tread is $66 \div 7 = 9\frac{3}{7}$ inches;
by rule II, the width of tread is $7 + 5 = 12$, and 5×2
= 10 inches.

(12) See Art. **43**, Fig. 37.

(13) From 6 to 7 inches.

(14) See Art. **60**.

(15) See Art. **16**.

(16) Distance $bc = 24 - 9 = 15$ in.; height $ce = \frac{15}{24}$ of 11 in. $= 6\frac{7}{8}$ in., which should be the distance scaled on diagram.

(17) See Art. **44**.

(18) (a) and (b) See Art. **61**.

(19) (a) and (b) See Art. **5**.

(20) See Art. **14**.

(21) (a) and (b) See Art. **19**.

(22) (a) and (b) See Art. **5**.

(23) See Art. **10**.

(24) (a) See Art. **9**.

(b) See Fig. 4.

(25) (a) and (b) See Art. **18**.

(26) See Art. **2**.

(27) (a) and (b) See Art. **8**.

(28) (a) and (b) See Art. **4**.

(29) See Art. **24**.

(30) See Art. **8**.

(31) See Art. **32**, Fig. 23 (d).

(32) (a) and (b) See Art. **4**.

(33) (*a*) and (*b*) See Art. **1**.

(34) (*a*) and (*b*) See Art. **20**.
(*c*) See Art. **22**.

(35) See Art. **39**, Fig. 30.

ESTIMATING AND CALCULATING QUANTITIES.

(QUESTIONS 1-56. SEC. 19.)

- (1) (*a*) and (*b*) See Art. **24**. Table.
- (2) (*a*) and (*b*) See Art. **28**.
- (3) (*a*) 62 cts. See Art. **11**.
(*b*) 12 cts. in addition to hauling. See Art. **11**.
- (4) (*a*) and (*b*) See Art. **59**.
- (5) (*a*) and (*b*) See Arts. **15** and **16**.
- (6) See Art. **53**.
- (7) See Art. **65** (cost of 1 sq. yd. of cellar floor).
- (8) See Art. **49**.
- (9) See Art. **68**.
- (10) (*a*) and (*b*) See Art. **56**.
- (11) See "Cost," Art. **67**.
- (12) See Art. **10**, also Art. **65**.
- (13) See Art. **25**.
- (14) (*a*) and (*b*) See Art. **26**.
- (15) See Art. **22**.
- (16) (*a*) and (*b*) See Art. **7**.

(17) (a) 575. See Art. **13**.

(b) 39. See Art. **13**.

(18) See Art. **69**.

(19) (a) Granite, 6 sq. ft. ; bluestone, 8 sq. ft. ; sandstone,
10 sq. ft.

(b) 25%.

(20) (a) See Art. **21**.

(b) See Art. **22**.

(21) (a) and (b) See Art. **2**

(22) (a) and (b) See Art. **46**.

(23) (a) About $11\frac{1}{2}\%$. See Art. **48**.

(b) See Art. **48**.

(24) (a) and (b) See Art. **26**.

(25) (a) and (b) See Art. **60**.

(26) See Arts. **44** and **45**.

(27) (a) and (b) See Art. **4**.

(28) (a) and (b) See Art. **41**.

(29) (a) and (b) See Art. **5**.

(30) (a) and (b) See Art. **27**.

(31) (a) and (b) See Art. **17**.

(32) (a), (b), and (c) See Art. **62**.

(33) (a) and (b) See Arts. **42** and **43**.

(34) (a) and (b) See Art. **61**.

(35) (a) and (b) See Art. **26**.

(36) (a) and (b) See Art. **40**.

(37) See Art. **65**.

(38) (a) and (b) See Art. **51**.

(39) (a), (b), and (c) See Art. **23**.

(40) (a) and (b) See Arts. **17** and **18**.

- (41) (*a*) and (*b*) See Art. **59**.
- (42) (*a*) and (*b*) See Art. **38**.
- (43) (*a*) and (*b*) See Art. **9**.
- (44) (*a*), (*b*), and (*c*) See Art. **20**.
- (45) (*a*) and (*b*) See Art. **47**.
- (46) (*a*), (*b*), and (*c*) See Art. **14**.
- (47) See Art. **41**.
- (48) (*a*), (*b*), and (*c*) See Art. **6**.
- (49) See Art. **27**.
- (50) (*a*), (*b*), and (*c*) See Art. **19**.
- (51) (*a*), (*b*), and (*c*) See Arts. **36** and **37**.
- (52) (*a*) and (*b*) See Art. **13**.
- (53) (*a*) and (*b*) See Arts. **31** and **34**.
- (54) See Art. **39**.
- (55) See Art. **40**.
- (56) (*a*) and (*b*) See Art. **58**.

SPECIFICATIONS.

(QUESTIONS 1-48. SEC. 23.)

(1) See Art. **1**.

(2) See Art. **1**.

(3) See Art. **1**.

(4) See Art. **1**.

(5) See Arts. **1** and **3**.

(6) See Art. **12**.

(7) The headings should in general be placed in the order in which the work will be executed. See Art. **1**.

(8) See Art. **1**.

(9) See Art. **2**.

(10) See at the end of Art. **26** under the heading "Heating."

(11) See Art. **5**.

(12) See Art. **5**.

(13) See Art. **18**.

(14) See Art. **2**.

(15) $\frac{1}{4}$ inch. See Art. **13**, "Ashlar Facing."

(16) See Arts. **20** and **26**.

- (17) See Art. 2.
- (18) See Art. 2.
- (19) To be under the frost line. See Art. 12, "Excavations."
- (20) See Art. 14, "Whitewashing."
- (21) See Art. 15, "Lathing."
- (22) See Art. 18, "Finished Floors."
- (23) See Art. 23.
- (24) See Arts. 16 and 18.
- (25) See Art. 12, "Excavations."
- (26) See Art. 25.
- (27) See Art. 14, "Chimneys."
- (28) See Art. 24, last paragraph.
- (29) See Art. 19.
- (30) See Art. 23, "Joints in Cast-Iron Pipe."
- (31) See Art. 27.
- (32) See Art. 28.
- (33) See Art. 28.
- (34) See Arts. 13 and 14.
- (35) See Art. 16, "Shingles."
- (36) See Art. 28.
- (37) See Art. 13, "Ashlar Facing."
- (38) See Art. 18, "Window Frames."
- (39) See Art. 22, "Leaders," and Art. 23, "Arrangement of System."
- (40) See Art. 20, "Mantels."

- (41) See Art. **23**.
- (42) Consult Arts. **12** and **13**.
- (43) Consult Art. **19**.
- (44) Consult Art. **23**.
- (45) Consult Art. **18**.
- (46) See Art. **16**, "Shingles."
- (47) See Art. **27**.
- (48) See Arts. **5** to **11**.

INDEX

NOTE.—All items in this index refer first to the section and then to the page of the section. Thus, "Ash 9 24" means that ash will be found on page 24 of section 9.

A	Sec.	Page		Sec.	Page
Accurate estimate	19	4	Beach	9	28
Acrogenous trees	9	3	Beads, Angle	23	34
Alphabet, Block-letter	13	25	Beam casing	23	33
" Egyptian	14	9	Bell roof	9	80
Angle beads	23	34	Bells, Specifications for	23	57
" newel	11	18	Bending by steaming	10	77
" To bisect	13	33	" wood	10	73
Annunciators, Specifications for	23	58	Birch	9	26
Apple wood	9	29	Bisect a straight line	13	28
Approximate estimating	19	3	" an angle	13	33
Apron	10	33	Black birch	9	26
Arc of circle equal in length to given straight line	13	41	" walnut	9	25
" circle given, To find straight line of same length	13	42	Blind hardware	23	41
" To find center of	13	38	" nailing	9	55
Arches, Centers for	9	116	Blinds	10	83
" Specifications for	23	22	" 	19	37
Architectural drawing	14	1	" Hinging outside	10	92
Architrave	10	14	" Inside folding	10	85
Area drains	23	45	" Outside folding	10	87
" of floors, Specifications for	23	12	" Specifications for	23	30
Areas, Specifications for	23	14	Block-letter alphabet	13	25
Ash	9	24	Blueprinting	14	88
Ashlar, Data on	19	15	Bluestone, Specifications for	23	16
" " " 	19	58	Board measure	19	20
" facings, Specifications for	23	15	Boiler, Specifications for	23	49
Axis of helix	13	46	Bolt, Square-headed	13	58
" " parabola	13	45	Bolts and keys	23	40
B			Bond in masonry	14	69
Backing of veneer	10	76	Bookcases, Specifications for	23	33
Balloon frame	9	31	Bow-pen	13	9
" " construction	9	100	" pencil	13	9
" framing	9	100	Boxed newel	11	18
Balusters	11	19	Boxwood	9	29
Balustrades	11	18	Braced frame	9	31
Barge boards	23	27	Bracketed stairway	11	6
Baseboard	14	15	Brackets, Specifications for	23	22
Bases or skirtings	10	15	Brick noggs	9	107
Basswood	9	29	" set furnace, Specifications for	23	18
Bathtubs, Specifications for	23	48	Brickwork, Data of	19	18
			" Estimate of	19	60
			" " " 	19	70
			" Specifications for	23	17

	<i>Sec.</i>	<i>Page</i>		<i>Sec.</i>	<i>Page</i>
Bridge joint	9	38	Cherry	9	26
" tenon	9	38	Chestnut	9	27
Bridging floorbeams	9	53	Chimney, Specifications for	23	18
" Specifications for	23	25	Circle, to find center with arc and radius given	13	39
Building materials, Cost of, per square foot	19	22	Circular siding	9	111
Buildings, Cost of, per cubic foot	19	4	" stairway	11	53
Bull-nose step	11	3	Circumference, to pass through any three points not in same straight line	13	39
" "	11	33	Cisterns, Specifications for	23	47
Burl	9	25	Clamping	10	13
Butler's pantry	10	96	Close stringer	11	6
Butt joint	10	3	" "	11	39
" joints	9	32	Closet, Dressing-room	23	37
Butternut	9	27	" Kitchen	23	37
Buttonwood	9	28	" Laundry	23	37
			" Linen	23	37
			" Specifications for	23	36
C			Clothes post	23	28
Caps of stone pillars	23	16	Coal bin, Specifications for	23	38
Carolina pine	9	22	slide, Specifications for	23	12
Carpenter work, Inside	23	29	Cold-air duct	23	53
" Specifications for	23	23	" Specifications for	23	18
Carpentry	9	1	Collar beams	23	25
" Cost of miscellaneous items of	19	25	Columns, Cast-iron	9	140
" Estimate of	19	19	" Specifications for	23	33
" " "	19	63	Compasses	13	6
Carriage timbers	11	33	Concrete, Specifications for	23	11
Carriages (stair building)	11	5	Cone, Element of	13	66
Carving, Specifications for	23	38	" Intersection of, by plane	13	66
Casement windows	14	40	Conic Sections: Drawing Plate	13	66
Cast-iron columns	9	140	Conical roof	9	75
" cylindrical ring	13	59	" surfaces, Development of	13	72
" pipe, Joints in	23	43	Construction, Slow-burning	9	132
" " Specifications for	23	43	Constructive Details: Drawing Plate	14	52
Caul	10	79	Corner, Shouldered	10	5
Cavetto	14	4	Cornice, Wood	23	33
Cedar	9	23	Cornices, Measurement of	19	22
Ceiled wainscot	23	32	" Specifications for	23	22
Ceiling, Finish of	23	56	" " "	23	27
" Groined	9	125	Cost of buildings per cubic foot	19	4
" Specifications for	23	28	" " materials per square foot of surface	19	22
Cellar bottoms, Specifications for	23	11	Cove	14	4
" sink, Specifications for	23	49	Cross-furring	9	61
" stairs	23	35	Cup shapes	9	9
" water closet	23	39	Curtail step	11	3
" Woodwork in	23	38	" " "	11	44
Cement finish, Specifications for	23	22	" " Description of curves of	11	44
Center lines	13	53	Curved risers	11	14
Centers, Elliptical	9	117	" " "	11	48
" for arches	9	116	" stringers	11	42
" Specifications for	23	22	" walls, Windows in	10	48
" Trimmer-arch	9	118			
Cesspool dome, Specifications for	23	18			
" Specifications for	23	13			
Chamfering	9	115			
Cheek-cut	9	69			

INDEX

ix

	<i>Sec.</i>	<i>Page</i>
Curved work, Laminated	10	76
Curves, Easement	11	29
" of curtail step, Description of	11	44
" Irregular	13	15
Cut-and-mitered stringer	11	6
" stone, Data of	19	15
" " " " " " "	19	58
" " work, Specifications for	23	16
Cylinder	13	56
" " " " " " "	13	64
" Intersection of, by plane .	13	66
Cylinders for stairways, Construction of	11	16
Cylindrical ring, Cast-iron	13	59
" surfaces, two equal, Intersections of	13	68
" surfaces, two unequal, Intersections of	13	68
Cyma recta	14	5
" reversa	14	5
Cypress	9	23

D

Dado joint	10	6
Dadoes and wainscots	10	16
Damp course, Specifications for	23	14
Dark surface	13	74
Débris, Meaning of, in specifications	23	
Description of arches	14	10
" " " Drawing Plate	14	10
Details: Drawing Plate	14	16
" of Vestibule: Drawing Plate	14	24
" of stairways	11	17
Development of conical surfaces	13	72
" " cylindrical surfaces	13	71
" " stringers	11	32
Dimensions	13	60
Distance piece	13	58
Dividers	13	9
Dog-leg stairway	11	4
Dome, Hemispherical	9	120
" Interior	9	124
Domes	9	120
Door, Cost of	19	39
" " " 	19	78
" Dutch	23	31
" frame, Cost of	19	39
" " " " 	19	77
" frames, Specifications for	23	31
" glazing	23	39
" hardware	23	44

	Sec.	Page
Door making	10	23
" Rear-veranda entrance	14	16
" stops	23	41
Doors	19	37
" Folding	10	29
" Sliding	10	27
" Specifications for	23	31
Dormer-window	14	7
" windows	9	96
Double-pitch roof	9	66
" platform	11	51
" winders	11	31
Dovetail	9	37
" Blind or secret	10	9
" Halving	9	37
" mortise	9	37
Dovetailed joint	10	7
Doweled joint	10	11
Drafting-room practice	14	93
Drain, House	23	45
Drainage system	19	43
" "	19	92
Drains, Area	23	45
" Specifications for	23	45
" subsoil and leader, Specifications for	23	12
Draw-bore pin	9	33
Drawing, Architectural	14	1
" board	13	1
" Definition of	13	1
" Freehand	13	1
" Geometrical	13	1
" ink	13	13
" Instruments and materials required for	13	1
" Mechanical	13	1
" paper	13	10
" pen, To sharpen	13	14
" pencils	13	10
" Projection	13	49
Dressed lumber	9	8
Dressing-room closet	23	37
Drift pins	9	134
Dry cesspool, Specifications for	23	13
" shrinkage	9	19
Duct, Cold-air	23	53
Dumb waiter, Specifications for	23	36
Dutch door	23	31

E

Earthen house sewer	23	44
Easement curves	11	29
Easements	11	20
Eaves	9	66
Ebony	9	30
Echinus	14	5

xi

J	
Jack rafters	9 69
Jamb lining	14 63
Joinery	10 1

	<i>Sec.</i>	<i>Page</i>		<i>Sec.</i>	<i>Page</i>
Joinery details	19	37	Ledger boards	23	25
" Estimate of	19	37	Left-hand stairway	11	3
" "	19	77	Lettering	13	18
" Exterior	10	101	Light Surface	13	74
" Province of	10	1	Lignum vitæ	9	30
Joint, Blind or secret dovetail	10	9	Linden	9	29
" Dado	10	6	Linen closet	23	37
" Dovetail	10	7	Lines, Center	13	53
" Doweled	10	11	" Character of	13	48
" Half-lap dovetail	10	8	" Shade	13	73
" Housed	10	6	Locust	9	25
" Lap dovetail	10	8	Long-leaved pine	9	21
" Miter	10	5	Loose joints	10	2
" Mortise-and-tenon	9	33			
" " "	10	12	M		
" Scarf	9	43	Mahogany	9	29
" Shouldered-and-mitered	10	5	Main stairs	23	34
" Straddle or bridge	9	38	Mansard roof	9	72
" Tongued-and-grooved	10	6	Mantels, Specifications for	23	36
Joints	9	32	Maple	9	26
"	10	2	Mason work, inside, Preparations		
" Glued	10	3	for	23	21
" in cast-iron pipe	23	43	Masonry, Estimate of	19	13
" Loose	10	2	" " "	19	55
" Spliced	9	36	" Specifications for	23	10
Joists, Attic floor	23	25	Materials put in place per day	19	24
" First and second story	23	24	" used in stairway con-		
			struction	11	2
K			Mechanical drawing	13	1
Kerfing	10	74	Mensuration of roofs	19	31
Keying	10	75	Mitered joint	10	5
Keys and keying	10	12	Miters, Hunting	10	73
Kiln-drying	9	19	Moldings: Drawing Plate	14	4
King's Windsor cement finish	23	22	" for stairways	11	17
Kitchen closet	23	37	" Nosed and mitered	11	6
" dressers	19	38	" Picture	23	33
" sink, Specifications for	23	49	Mortar, Specifications for	23	11
			Mortise	9	33
L			" and-tenon joint	9	33
Ladder, Step	11	22	" " "	10	12
Laminated curved work	10	76	" Dovetail	9	37
Landing	11	3	Mullion	10	35
" Half-space	11	3	" Window: Drawing Plate	14	19
" Quarter-space	11	3			
Lap dovetail	10	8	N		
Lath, Expanded metal	23	21	Nails, Estimate of	19	25
Lathing	9	60	" Sizes and weights of	19	26
" Estimate of	19	36	Natural-wood finish	23	55
" Specifications for	23	21	Newel, Angle	11	18
Laundry closet	23	37	" between quarter cylinders	11	49
Lavatories, Specifications for	23	48	" Boxed	11	18
Lead pipes, Specifications for	23	44	" Half	11	39
Leader	9	92	" posts	11	18
" drains, Specifications for	23	12	" "	11	41
Leaders, Specifications for	23	42	" Special Arrangement of	11	41
" " "	23	46	" stairway	11	35
Lean-to	9	66	" Starting	11	18

	<i>Sec.</i>	<i>Page</i>		<i>Sec.</i>	<i>Page</i>
Newels	11	18	Pipe-casing, Specifications for . . .	23	38
Niches	9	131	" supports, Specifications for . . .	23	51
Nogs, Brick	9	107	Pipes, Coverings for	23	54
Northern pine	9	21	" Heater	23	53
Norway spruce	9	22	" Soil	23	45
Nosed and mitered moldings . . .	11	6	" Vent	23	45
Nosing	11	2	" Waste	23	45
O			Pitch board	11	8
Oak	9	24	" of helix	13	46
Objects, Representation of	13	48	Plan	13	51
Octagon, To inscribe, in a circle .	13	40	Plancher	9	76
Ogee roof	9	80	Plane tree	9	28
Open newel stairway	11	4	Plank stairway	11	72
" stringer	11	6	Plaster grounds	9	60
" "	11	37	" "	9	108
Ordinate of parabola	13	45	Plastering, Estimate of	19	35
Oval, Egg-shaped	13	42	" " "	19	75
Ovolo	14	5	" on the outside	23	23
P			Specifications for	23	21
Painting, Cost of	19	48	Plate I	13	27
" Data on	19	46	" I, Hints for	13	32
" Estimate of	19	46	" II	13	33
" " "	19	95	" III	13	37
" Exterior	23	55	" IV	13	39
" Interior	23	55	Plates	23	25
" Ironwork	23	55	" Preliminary directions for		
" Specifications for	23	54	drawing	13	26
Pantry, Butler's	10	96	Platform, Double	11	51
" sink, Specifications for . . .	23	49	" Half-turn	11	49
Paper used in drawing	13	10	" stairway	11	25
Papering, Estimate of	19	49	" "	11	52
Parabola, Axis of	13	45	" " with two return		
" Definition of	13	45	flights	11	52
" To draw	13	45	Platforms (stair building)	11	14
Parallel to straight line, To draw .	13	30	Plinth blocks	10	15
Parallelogram, To draw	13	37	Plumb-cut	9	69
Partition sills and plates	23	25	Plumbing, Estimate of	19	43
Partitions	9	57	" " "	19	91
" Interior	9	137	" fixtures	19	45
" Specifications for	23	24	" "	23	47
" Trussed	9	62	" "	23	48
Patching of plaster work, Specifi-			" Specifications for	23	43
cations for	23	23	" system, Arrangement of . . .	23	46
Pear wood	9	29	" Tests of	23	44
Pencils, how sharpened	13	10	Polygon, To construct, one side		
" used in drawing	13	10	being given	13	41
Pendentives	9	128	" To inscribe, in a circle . . .	13	40
Pens, Ruling or right-line	13	11	Porch timbers	23	25
Pentagon, To inscribe, in a circle	13	39	Porte-cochère timbers	23	25
Perpendicular to a straight line,			Posts	9	50
To draw	13	29	"	23	24
Picture moldings	23	33	" Veranda	9	114
Pin balusters	11	19	Preliminary estimate	19	3
" Draw-bore	9	33	Preparation for tiling	23	20
Pine	9	21	Prime cost, Meaning of, in speci-		
			fications	23	2

	<i>Sec.</i>	<i>Page</i>		<i>Sec.</i>	<i>Page</i>
Privy, Specifications for	23	28	Risers, Curved	11	14
Prism, Hexagonal	13	56	" "	11	48
" "	13	63	" Height of	11	6
" Rectangular	13	55	Rivet	13	57
" "	13	62	Roof, Bell	9	80
Projection	13	50	" Conical	9	75
" drawing	13	49	" Double pitch or gable	9	66
Projections I: Drawing Plate	13	55	" Flat	9	66
" II: Drawing Plate	13	62	" Gambrel	9	71
Properties of wood	9	20	" Gravel	19	31
Protractor	13	18	" Hexagonal	9	79
Pulley stiles	14	39	" Hip	9	67
Purlins	9	84	" Mansard	9	72
Pyramid, Hexagonal	13	57	" mensuration	19	31
" "	13	63	" Ogee	9	80
			" Single-pitch	8	66
Q			" Specifications for	23	26
Quarter-platform stairway	11	47	Roofing, Estimate of	19	27
" " with newels	11	52	" " "	19	74
" " with semicircular cylinder	11	50	Roofs, Construction of	9	88
" " with step	11	51	" Framing of	9	65
" " with tangent between quarter cylinders	11	50	" Tile	19	31
" rounds	14	5	" Tin	19	30
" space landing	11	3	Rosewood	9	30
" turn winding	11	48	Rubbish, Meaning of, in specifications	23	3
R			Rubble masonry, Data on	19	14
Rafters	23	25	" " "	19	57
" Hip	9	69	Ruling pen	13	11
" Jack	9	69	Run (stair building)	11	3
Rails, Hand	11	20			
Ramps	11	20	S		
Rear stairs	23	35	Saddle, Specifications for	23	32
Rectangular prism	13	55	Safes, Specifications for	23	46
" "	13	62	Sash	10	38
Red cedar	9	23	" "	19	37
" oak	9	24	" Fixed and movable	10	31
Redwood	9	23	" glazing	23	39
Refrigerator, Specifications for	23	50	" hardware	23	40
" waste	23	46	" Hinged	10	46
Registers, Specifications for	23	20	" making	10	41
" " "	23	54	" Specifications for	23	30
Resawed lumber	9	8	Saw kerfing	10	74
Residence, Two-story brick and frame	14	31	Sawing, Methods of	9	17
Ridge boards	9	95	Scale	13	17
" roll	9	95	Scales, Use of	14	1
Ridges	23	25	Scarf joints	9	43
Right-hand stairway	11	3	Scarfig	9	41
" line pen	13	11	Schedule, Estimating	19	2
Ring, Cylindrical	13	59	" "	19	4
Riser	11	2	Scotia	14	5
" "	11	6	Scribing wall stringers	11	11
Risers and treads, Proportioning	11	7	Seasoning of timber	9	19
			Second-Story Plan: Drawing Plate	14	45
			Sectional Elevation: Drawing Plate	14	82

INDEX

xv

	<i>Sec. Page</i>		<i>Sec. Page</i>
Sectional views, Representation		Specifications for areas	23 14
of	14 8	" " ashlar facings	23 15
Sewer, Earthen house	23 44	" " barge boards	23 27
Shade lines	13 74	" " bathtubs	23 48
Sheathing	9 105	" " bells	23 57
" Calculation of	19 21	" " blinds	23 30
" " " "	19 70	" " bluestone	23 16
" lath, Specifications for	23 26	" " boiler	23 49
" paper, Specifications for	23 26	" " bolts and keys	23 40
" Specifications for	23 26	" " bookcases	23 33
Shingle staining	23 55	" " brick-set furnace	23 18
Shingles, Data on	19 27	" " brickwork	23 17
" Estimate of	19 27	" " bridging	23 25
" " " "	19 70	" " carpenter work	23 23
" Method of laying	9 90	" " carving, composition, etc	23 33
" Specifications for	23 26	" " cast-iron pipe	23 43
" " " "	23 40	" " ceiling	23 28
" Shouldered corner	10 5	" " cellar bottom	23 11
Shutters	10 83	" " cellar water closet	23 39
Side elevation	13 52	" " cement finish	23 22
" view	13 52	" " centers	23 22
Siding	9 109	" " cesspool	23 13
" Circular	9 111	" " " dome	23 18
" Estimate of	19 22	" " chimneys	23 18
" Specifications for	23 27	" " cisterns	23 47
Sills	9 50	" " closets	23 36
"	23 24	" " clothes posts	23 28
Single-pitch roof	9 66	" " coal bins	23 38
" spruce	9 22	" " " slide	23 12
Sink, Cellar	23 49	" " columns and screen	23 33
" Kitchen	23 49	" " cornices	23 22
" Pantry	23 49	" " "	23 27
" Slop	23 49	" " cut-stone work	23 16
Sizes, Meaning of, in specifications	23 2	" " damp course	23 14
Skirting	14 15	" " door frames	23 31
Skirtings	10 15	" " doors	23 31
Slates, Number of, per square	19 29	" " drains	23 45
Slating, Data on	19 28	" " dumb waiter	23 36
" " " "	19 74	" " electrical work	23 56
Sliding doors	10 27	" " excavations	23 10
Slop sink, Specifications for	23 49	" " facing	23 15
Slow-burning construction	9 132	" " fences	23 29
Smoke pipe	23 53	" " finish of wall	23 22
Soil pipe, Specifications for	23 45	" " finished floors	23 29
Southern pine	9 22	" " fireplaces	23 19
Speaking tubes	23 58	" " flashings	23 41
Specification, Heading of	23 5	" " footings	23 14
" of plaster work	23 23	" " foundation walls	23 14
" Purpose of	23 1	" " framing	23 24
" Terms used in	23 2	" " front or street wall	23 14
Specifications for angle beads	23 34	" " furnace	23 53
" " annunciators	23 58	" " " pits	23 18
" " arches, brackets, etc	23 22		
" " area floors and pavements	23 12		

	<i>Sec.</i>	<i>Page</i>		<i>Sec.</i>	<i>Page</i>
Specifications for gas-fittings . . .	23	52	Specifications for sheathing paper	23	26
" " gate pillars and			" " shingles	23	26
wheel guards	23	16	" " siding	23	27
" " glazing	23	39	" " sink in cellar . .	23	49
" " grounds, fur-			" " slop sink	23	49
ring, etc.	23	25	" " soil pipe	23	45
" " gutters	23	42	" " speaking tubes .	23	58
" " hall seats	23	33	" " stairs	23	34
" " hardware	23	39	" " subsoil drains .	23	12
" " heater pipes . . .	23	53	" " swing shelves .	23	39
" " heating	23	53	" " temporary privy	23	28
" " hinges	23	40	" " timber	23	24
" " inside carpenter			" " tinners' work . .	23	41
work	23	29	" " traps	23	44
" " inside mason			" " "	23	46
work	23	21	" " trimmer arches		
" " inside trim and			and hearth . . .	23	20
base	23	32	" " trussed parti-		
" " interior finish .	23	29	tions	23	24
" " ironwork	23	42	" " vent pipes	23	45
" " kitchen sink . . .	23	49	" " veranda	23	28
" " lathing	23	21	" " wainscoting . . .	23	32
" " lavatory	23	48	" " wall coping . . .	23	15
" " lead pipe	23	44	" " " treatment . .	23	56
" " leader drains . .	23	12	" " walls	23	13
" " leaders	23	42	" " wardrobes	23	37
" " "	23	46	" " wash trays	23	49
" " mantels	23	36	" " waste pipes . . .	23	45
" " masonry	23	10	" " water closets . .	23	48
" " mortar and con-			" " " supply	23	50
crete	23	11	" " " table	23	27
" " open timber			" " whitewashing .	23	20
work	23	27	" " window frames	23	30
" " outside finish . .	23	27	" " wiring system . .	23	57
" " painting	23	54	" " wood cornice,		
" " pantry sink . . .	23	49	beam casing,		
" " partitions	23	24	etc.	23	33
" " picture mold-			" " Form of	23	4
ings	23	33	" " General-condition		
" " pipe casing . . .	23	38	clause of	23	5
" " " supports . . .	23	51	Splayed work	10	56
" " plastering	23	21	Spliced joints	9	36
" " plastering on the			Splines	9	133
outside	23	23	Springing trees	11	5
" " plumbing	23	43	Spruce	9	22
" " refrigerator . . .	23	50	Square-headed bolt	13	58
" " registers	23	54	" " To inscribe, in a circle . .	13	38
" " registers and			" " Use of steel	9	85
thimbles	23	20	Stair building, Terms used in . .	11	2
" " roof	23	26	Stairs, Cellar	23	35
" " rough flooring .	23	26	" " Cost of	19	41
" " saddles	23	32	" " "	19	84
" " safes	23	46	" " Main	23	34
" " sash	23	30	" " Rear	23	35
" " sheathing	23	26	" " Specifications for	23	34
" " " lath	23	26	Stairway, Bracketed	11	6

xvii

	<i>Sec.</i>	<i>Page</i>		<i>Sec.</i>	<i>Page</i>
Stairway, Circular	11	53	Stringer, Open	11	37
" construction, Materials			" Wall	11	5
" used in	11	2	Stringers, Curved	11	42
" design and construction	11	22	" Development of	11	32
" Dog-leg	11	4	" Laying out of	11	8
" Elliptic	11	53	Stucco work	19	35
" Geometrical	11	4	Studs	9	50
" " 	11	24	" 	9	57
" Left-hand	11	3	" 	23	24
" Newel	11	35	" Double	9	64
" Open newel	11	4	" joints, rafters, etc., Calcula-		
" Plank	11	22	tions of	19	20
" Platform	11	25	Subsoil drains, Specifications for .	23	12
" " 	11	52	Surface, Dark	13	74
" Quarter-platform	11	47	" Light	13	74
" Right-hand	11	3	Swan neck	11	21
" Straight	11	24	Swelled steps	11	13
" Winding	11	49	" " 	11	42
" with three-quarter turn	11	51	Swinging shelves, Specifications		
Stairways, Classification of	11	4	for	23	39
" Erection of	11	17	Sycamore	9	28
" Miscellaneous details of	11	17	System of wiring, Specifications		
" Special forms of	11	47	for	23	57
Steaming, Bending by	10	77			
Steel Columns and Connections:					
Drawing Plate	14	27			
" square, Use of	9	85	T square	13	2
Step, Bull-nose	11	3	Tail-beams	9	36
" " 	11	13	Tenon	9	33
" Curtail	11	3	" Bridge	9	38
" " 	11	44	Tenons, Tusk	9	36
" ladder	11	22	Terms used in specifications . . .	23	2
" Swelled	11	3	Test of plumbing system	23	44
" " 	11	42	Thimbles, Specifications for . . .	23	20
Steps, Construction of	11	12	Throat of leader	9	93
Stirrup irons	9	36	Ties	23	25
Stone cutter, Day's work of	19	17	Tile roofs	19	31
" masonry, Measurement of .	19	13	Tiling, Preparation for	23	20
" pillars, Caps for	23	16	Timber, Properties of	9	2
Store front	10	101	" used in carpenter work,		
Straddle joint	9	38	Size of	23	24
Straight line, equal in length to			" work, Open	23	27
arc of circle	13	41	Timbers, Carriage	11	33
" " To bisect	13	28	" for veranda, porte co-		
" " To divide, into equal			chère, and porch	23	25
parts	13	34	" Specifications for	23	24
" " To draw a parallel to	13	30	Tongued-and-grooved joint	10	6
" " To draw a perpen-			Top view	13	51
dicular to	13	29	Torus molding	14	4
" run stairway	11	24	Tracings	14	87
Street wall, Specifications for	23	14	Trap, Main drain	23	44
Stringer, Close	11	6	" Specifications for	23	44
" " 	11	39	" " 	23	46
" Cut-and-mitered	11	6	Tread	11	2
" Housed	11	6	Treads and risers, Proportioning .	11	7
" Open	11	6	" Winding	11	29
			Treenail	9	33

	<i>Sec.</i>	<i>Page</i>		<i>Sec.</i>	<i>Page</i>
Triangle, Equilateral	13	36	Water closet, Cellar	23	39
" To draw, when two sides			" closets, Specifications for . .	23	48
and included angle are			" supply, Specifications for . .	23	50
given	13	37	" " system	19	44
Triangles	13	3	" table	9	110
Triglyph	14	67	" " Specifications for . .	23	27
Trim, Interior	10	14	Weather boarding, Estimate of . .	19	22
Trimmer-arch centers	9	118	" check	14	63
" " Specifications for . .	23	20	Wedge	13	55
beams	9	53	Well supply	19	45
Trimmers	9	36	Well hole	11	4
" 	23	25	Wheel guard, Specifications for . .	23	16
Tin roof, Data of	19	30	White birch	9	26
Tinners' work, Specifications for . .	23	41	" cedar	9	23
Trussed partitions	9	62	" deal	9	22
" " Specifications			" oak	9	24
for	23	24	" pine	9	21
Tubes, Speaking	23	58	" spruce	9	22
Tusk tenons	9	36	Whitewood	9	28
V			Whitewashing, Specifications for . .	23	20
Valley, Definition of	14	48	Winders	11	3
" rafters	23	25	" Arrangement of	11	33
Veneer backing	10	76	" Double	11	31
Veneeting	10	77	" Starting or landing	11	52
Veneers	10	78	" Width of	11	31
Vent pipes, Specifications for . .	23	45	Winding, Quarter-turn	11	48
Ventilating system, Estimate of . .	19	42	" stairway	11	49
" " " " " " " "		88	" " with three-quarter		
Veranda, Cost of	19	41	turn	11	51
" Specifications for	23	28	Window casement	14	40
timbers	23	25	" Cost of	19	40
Verandas	9	112	" Dormer	14	77
Vertex of parabola	13	45	" Eyebrow	9	97
Vestibule, Details of	14	24	" for brick walls, Details of . .	14	16
View, Side	13	52	" frame, Cost of	19	40
" Top	13	51	" " " " " " "	19	80
W			" frames, Specifications for . .	23	30
Wainscot, Ceiled	23	32	" glass, Panes of, in box . .	19	51
Wainscoting	19	37	" " Table of sizes of . .	10	39
" 	11	54	" Mullion	14	9
" Specifications for	23	32	Windows	10	31
Wainscots	10	16	" Dormer	9	96
Wall coping, Specifications for . .	23	15	" in curved walls	10	48
" stringers	11	5	Winding treads	11	29
" " Scribing	11	11	Wiring system, Specifications for . .	23	57
" treatment, Specifications for . .	23	56	Wood bending	10	73
Walls, Specifications for	23	13	" cornice	23	33
Walnut, Black	9	25	" Evergreen	9	21
Wardrobes	19	38	Woods, Properties of	9	20
" Specifications for	23	37	Woodwork in cellar	23	38
Washer, Square cast-iron	13	58	Y		
Wash trays, Specifications for . .	23	49	Yellow pine	9	22
" tubs	10	95	Z		
Waste pipes, Specifications for . .	23	45	Z bars	14	29

